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PROFESSORS B. SILLIMAN, B. SILLIMAN, JR.,

AND

JAMES D. DANA.

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ERRATA.

P. 18, l. 16 from bottom, for "space," read "sphere," P. 22, l. 5 from top, substitute f for f. P. 23, l. 13 from bottom, for "any portion of *cgrs*," read "any portion *cgrs*." P. 24, l. 15 from top, for $\frac{d^2P}{ds}d\varphi$ read $\frac{d^2P}{ds\,d\varphi}d\varphi$. Page 33, line 8 from bottom, for πKR^2 read $2\pi KR^2$. P. 34, l. 4 from top, for $\frac{d^2Q'}{dt}$ read $\frac{d^2Q'}{dt^2}$.

P. 97, 9th l. from bottom, for *Lagostoma nodosa*, read *Lagostoma perlatus*.

P. 108, l. 12 from bottom, for "anilene," read "amilene." P. 110, line 22 from bottom, for "$C_{14}H_5O_4+4HO$," read "$C_{20}H_6O_6+4HO$." P. 112, l. 19 from bottom, for "urthethan," read "urethan."

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April, 1849.

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New Haven, January 1, 1851. B. SILLIMAN, Senior.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. I.—*Comparison of Experiments on American and Foreign Building Stones to determine their relative strength and durability;* by Prof. WALTER R. JOHNSON, of Washington, D. C.

As we have in the United States but few ancient buildings, the age of which can furnish conclusive proofs of the durability of their materials, and as but few of the materials which are found in such abundance and variety in this country, have been subjected to any satisfactory experimental tests to prove either their strength or durability, it is desirable that a rigorous comparison should be made, not only between the results of such trials on American rocks as have been made, but also between them, and such foreign materials as have been tested by the most careful experimenters, and have besides undergone the more decisive proofs of many centuries of use in public edifices and monuments. As nature has in many situations exposed these various materials to the direct action of all the causes which can work their gradual destruction, and as these destructive causes have evidently wrought with an efficacy on some rocks vastly greater than on others, it is clear that if we would ascend to the highest and most reliable proofs of durability, we must seek for them in the condition which the rocks themselves have been able to maintain, not for the few brief centuries to which the memory of man extends, but during the geological ages which run back immeasurably beyond all human history. Those rocks which amidst the denuding, disintegrating and decomposing influences, whether derived from sweeping currents of water, from meteoric actions and changes of temperature, or from vegetable growth

and decay, have been able to sustain themselves in high, bold, naked, angular cliffs, unprotected by soil, and yet unfurrowed by irregular disintegration, are manifestly those to which the engineer and architect are to direct their attention, when they seek materials for durable works of art. On the other hand, they will shun those rocks which the causes above enumerated have kept constantly down to a level with the ground, or which barely rise in some few patches to the surface, and are there seen disintegrating, scaling away, and covering themselves with a soil derived from their own debris.

The chemistry of geology furnishes to the architect and engineer most important hints for guiding their selection of materials; hints which when taken with other tests and proofs, leave them without excuse for choosing those of an inferior character. The influence of such a substance as iron pyrites on the durability of rocks in which it occurs, is so well known to every one acquainted with even the rudiments of geology and mineralogical chemistry, as scarcely to need a formal statement.* The effect of carbonic acid with water in dissolving carbonate of lime, and the readiness with which it acts on loosely aggregated crystalline masses of that carbonate, to effect their disintegration, may be understood from any elementary work on chemistry. The greater solubility of sulphate than of carbonate of lime may be ascertained from the same source. The weakness of coarsely crystallized stones as compared with those of finer texture, is so well known as to be properly classed among the canons of architecture.†

Of all the purposes for which building materials are employed, that which requires the utmost attention to durability is the erection of national monuments. It is a mockery to the dead, and an opprobrium to the living to put perishable materials into structures professing to perpetuate the virtue of great and good men. The Spanish nation is represented to have recently determined on the erection of a magnificent statue of bronze to rest on a base of rose granite, the most enduring of that species of rock, to commemorate the glory of Columbus.

The question of the strength of a material to resist a crushing force is sometimes a vital one, as has been painfully proved within a year or two past in some of our large cities, where extensive warehouses have been crushed beneath their own weight and that of the goods which they contained, occasioning fearful losses of life. But the crushing test has by no means a single aim. It looks to the relation between the cohesion of a material and its capacity to resist the action of other than mechanical causes of

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* "Pyrites when present (in granite) renders the rock unfit for use, as it decomposes and stains or rusts the surface, besides loosening the grains and causing the rock to fall to pieces."—*Dana's Mineralogy*, p. 579.

† Borgni's "Constructions Diverses," p. 23, and Rondelet's "Art de Batir."

disintegration. It is certainly a most egregious mistake to construct any tall public edifice in such a manner as not to sustain its own dead weight, but there are operations scarcely less discreditable, and which apply with equal force to structures professing to be enduring whatever be their height, their form, proportions or weight.

The usual trial of materials in small cubes is intended to furnish the relative strength or durability of the several species of materials to which it is applied.

The stone used in the Washington National Monument, and referred to in the following comparisons of experiments, is the same as that mentioned under the name of "*alum limestone*," in the report of the building committee to the Regents of the Smithsonian Institution, Dec. 7, 1847.

"The marble quarries of Maryland, chiefly in the vicinity of the village of Clarksville, about thirteen miles from Baltimore, on the line of the Susquehanna Railroad, contain two qualities of marble; one fine grained and of beautiful uniform color, approaching the character of statuary marble; the other of inferior quality, similar to the Sing Sing marble employed in New York in Grace Church and other public structures, of a somewhat coarse and highly crystalline structure, and known to the quarrymen here under the name of 'alum limestone.'"*

Trials of these two kinds of stone by the the process of Brard† were made by Dr. Page in 1847, and shewed that "an inch cube of the fine-grained marble lost in four weeks about one-fifth of a grain; and a cube of the best quality of the 'alum stone,' or coarse-grained marble *from half a grain to a grain and a half*."‡

This indicated with sufficient clearness the inferior durability of the coarse-grained stone; since it underwent from *two and a half* to *seven and a half* times as much disintegration as the fine-grained variety. The fine-grained stone is understood to be derived from the Taylor quarries, half a mile westward of Cockeysville, and about a mile distant from the Griscom lime quarries which are at a place called Texas, where the "alum limestone" used at the National Monument is procured. At the latter quarries the stone is worked wholly below the original surface of the ground. At a few points along the outcropping edge of the bed, the harder parts of the rock come to the surface of the ground or rise occasionally one or two feet above it, covered in places with loose granules of the same rock. In some parts it is eroded into sloping channels, lined with skeletons of crystals and their slightly cohering nuclei.

On removing the soil, the rock is found with alternating peaks and cavities: its surfaces are more or less deeply tinged with the

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* Hints on Public Architecture, by R. D. Owen, p. 114.

† Ann. de Chim. et de Phys., tom. 38.

‡ Owen, p. 116.

oxyd of iron derived from decomposed iron pyrites, many veins of which traverse it in various directions, and the skeleton crystals with loosely cohering nuclei are even more conspicuous than at the points where the rock crops out as above described.

That even the fine-grained stone above mentioned is not in all respects suitable to be employed as the casing stone of large shafts, is proved by the present condition of the shaft of the Washington Monument in Baltimore, where a similar stone from the same neighborhood was used. This monument was commenced on the 4th of July, 1815, and the statue was elevated on the 19th of October, 1829. On the 23d of October, 1850, or twenty-one years from the date of its completion, I examined from the platform at the base of the shaft the condition of its lower part.

There was seen on the side of the shaft opposite to the northeast corner of the base, a crack commencing near the bottom and following partly the joints of the masonry, and partly certain transverse or vertical cracks crossing the blocks of marble. The 3d, 5th, 8th, 10th, 11th, 13th, 14th, and 15th courses of stone, counting from the bottom, were seen to be broken either partly or wholly across, and in one instance a block is broken into three pieces. On the southeasterly side of the shaft is a second line of fracture crossing ten or twelve blocks, mostly alternating with the courses of masonry which have joints corresponding with the general course of the fissure. At the southwesterly side are fifteen blocks cracked either partly or wholly across, and forming a third fissure more or less in a zigzag direction, controlled apparently in some degree by the joints of the masonry. On the west side a fourth line of fracture appears to ascend some forty or fifty feet, and on the northwest side still a fifth line perhaps somewhat more irregular in direction than the preceding, but still easily traceable by the eye. In some cases where the cracks on two alternate blocks meet the joint of masonry in the course between them, the opening of that joint is apparent; in other words the crack is here in the cement, as might reasonably be expected. How long these cracks have existed, I have no means of ascertaining. But one thing seems certain, that alternate cold and heat, rain and frost, will, along these lines of fissure, produce their usual effects of thrusting farther and farther apart the masses which bound them. Time will reveal the effects, and perhaps expose the causes of these incipient dilapidations.

A chemical analysis of the "alum limestone" has been published by Dr. L. D. Gale, which makes the composition of that sample to be

Carbonate of lime, ...	98·6
Silica or other insoluble matter, . .	1·4
	100·

I have also found one very white specimen in which the insoluble matter was only 0·4 per cent., but even from the solution of this, ammonia threw down a slight brownish precipitate of oxyd of iron.

A specimen of the blue vein variety showed the following characters:—Its specific gravity was 2·708. 1218·4 grains pulverized and carefully washed, afforded a residue of 5·5 grains of iron pyrites (and an inappreciable quantity of adhering silica.) equal to 0·45 per cent. 100 grains treated with strong acetic acid, lost 73·7 per cent. Strong boiling nitric acid applied to the insoluble residue dissolved the pyrites, and the sulphuric acid thence produced was precipitated with chlorid of barium, giving 1·62 grains, equivalent to 0·42 grains of iron pyrites, agreeing very nearly with the mechanical analysis.

The acetate was dried up, converted into carbonate and then redissolved and precipitated with oxalate of ammonia, to separate the lime, after which ammonio-phosphate of soda threw down of phosphate of magnesia 1·3 grains, equivalent to 0·47 grain of magnesia, or to 0·97 grains of carbonate of magnesia. From this it should seem that the sample was composed of

Carbonate of lime, ...	72·73
Carbonate of magnesia, . . .	0·97
Sulphuret of iron, ...	0·42
Insoluble silicates, ...	25·88
	100·

As the pyrites is one of the chief coloring matters of the dark veins, it is evidently very variably distributed through the stone. The crystals of sulphuret are mostly small, but easily detected, by the naked eye.

On breaking a weathered portion of the pyritous vein it is often found penetrated from one to two or three inches by the coloring matter (peroxyd of iron). On the interior parts of the discolored portion, the pyrites will be found but partially decomposed. On the outer portions it will have wholly given place to the peroxyd. On the fresh surfaces not reached by rust, the yellow pyrites remains unchanged.

When an attempt is made to polish a surface of the alum limestone, portions will occasionally be detected which from their softness render fruitless all attempts to impart lustre to them. On careful examination they will be found so soft as to be readily scratched with the finger nail. In many parts, little triangular cavities, from which it appears the last remnants of the solid angles of crystals have dropped out in the operations of cutting and polishing, will be easily discovered by the eye, and slight lines forming the boundaries of the large crystals are not unfrequently traceable when the piece is brought into a strong light. A block thus polished will have all its crystals of pyrites from their su-

perior hardness left slightly elevated above the surface of the carbonate of lime which is worn away in polishing.

The surface of polished stone thus variously marked with elevations and cavities, may be used like an engraver's plate, and will give an impression of its own markings, of much interest.

1. *Trials of two-inch cubes of the coarse-grained "alum limestone," used at the National Washington Monument, to ascertain its resistance to crushing. By Dr. Charles G. Page.*— The specimens were stated to have been furnished by the owner of the quarries, and the testing to have been performed by the aid of a "powerful hydraulic press," so arranged as to "indicate accurately the amount of pressure." Not having witnessed any of the experiments or the arrangements of the machine, the writer feels bound to say that these allegations respecting the machine have been published by the architect, by the superintendent, and by others concerned in building the monument at Washington. These experiments were communicated to the writer by Dr. Page.

No. of the trial.	Crushing weight in pounds per square inch.
1.	910
2.	1372
3.	2281
4.	2312
5.	2437
6.	2531
7.	2625
8.	2650
9.	2750
10.	2843
11.	2968
Average strength,	2334

Note.—From the above it appears that the greatest strength per square inch, when tested in two inch cubes is 2968 pounds, and the least 910 pounds, the latter being about 30 per cent. of the former number.

2. *Trials by Dr. Page, of other building materials* to obtain results, on two-inch cubes, comparable with those afforded by the "alum limestone."

No. of trial.	Kind of stone.	Crushing weight in lbs. per square inch.
1.	Fine-grained marble of Symington,	4562
2.	Another sample of do.	4400
3.	White veined marble, East Chester, N. Y., used at the General Post Office,	4081
4.	do. another specimen,	3906
5.	Italian marble,	3156

No. of trial.	Kind of stone.	Crushing weight in lbs. per. square inch.
6.	Patapsco granite,	2941
7.	" do. another specimen,	2593
8.	Seneca sandstone, (Smithsonian building,)	2691
9.	do. do. another specimen,	2691
10.	Stockbridge marble, Mass.,	2410
[11.	*Alum limestone*, (*casing of monument*,) average as above,	2334]
12.	Stockbridge marble, 2d specimen,	2093
13.	York road freestone, (a friable brown sandstone,)	2125
14.	Aquia Creek sandstone, (Patent Office,)	2093
15.	do. do. do. 2d specimen,	1875
16.	do. do. do. 3d do.	1441
17.	do. do. do. 4th do.	1234
18.	Common building brick,	1000

Arranging in order of the average strength, we have the following succession, a column of relative values being added in which the alum limestone is represented by 100.

	Kind of stone.	Average strength per square inch.	Relative value.
1.	Maryland fine-grained marble,	4481	192
2.	East Chester (N. Y.) marble,	3993	171
3.	Italian marble,	3156	135
4.	Patapsco granite,	2767	118
5.	Seneca (Smithsonian) stone,	2691	115
[6.	*Alum limestone* (monument),	2334	100]
7.	Stockbridge marble,	2251	96
8.	York-road freestone,	2125	91
9.	Aquia Creek (Patent Office) sandstone,	1660	71
10.	Common brick,	1000	42

Note.—The two sandstones, numbers 5 and 8, have a mean strength of 2408, which is three per cent. higher than that of the "alum limestone," which has its place between them in the above series. The four trials of the Aquia Creek sandstone give an average strength of 1660 pounds, and the first three experiments of Dr. Page on the alum limestone gave an average of 1521 pounds, showing the inferiority of at least some portions of this limestone to that "material which now disfigures the architecture of the Treasury building and the Patent Office."*

3. *Experiments on different building materials, published by Mr. Robert Mills*, architect of the Washington National Monument. Specimens of the same size as the preceding.

No. of trial.	Kind of stone.	Strength per square inch.	Relative value.
1.	Symington's fine-grain marble,	6344	271·
2.	Baltimore granite (Sumwalt and Grayson's),	6250	267·

* Hints on Public Architecture, p. 114.

No of trial.	Kind of stone.	Strength per square inch.	Relative value.
3.	Blue rock from Potomac, used as the backing stone of the National Monument,	3750	160
4.	Granite of the east (*Port Deposit*), .	3250	139
5.	Granite of Normandy,* . . .	2628	112
[6.	*Alum limestone* (monument), . .	2334	100]

4. *Marbles and limestones tested and Reported on by Mr. Rennie in England.*†

No. of trial.	Kind of stone.	Lbs. per sq. inch.	Relative value.
1.	White Italian veined marble (tried in 1½ inch cubes), ...	9681	414
2.	Black Brabant marble (tried in 1½ in. cubes,)	9281	395
3.	Purbeck stone, do.,	9160	392
4.	Black compact limestone, Limerick, Ireland, (tried in 1½ inch cubes,) . . .	8855	379
5.	Compact limestone, do., . . .	7713	330
6.	Devonshire red marble, do., . .	7187	308
7.	White statuary marble, not veined, do.,	6058	259
8.	White Italian veined marble, tried in one-inch cubes, ...	3216	137
[9.	*Alum limestone*, (as above,) . .	2334	100]

Note.—From his own reading of the original memoir of Mr. Rennie, the writer was led to suppose that all the above samples of stone, numbered from 1 to 6 inclusive, had been tested in two-inch cubes, and that the Numbers in the Philosophical Transactions (1818) referred to blocks of four square inches on the base; but in the Encyclopedia Britannica Mr. Tredgold has given the dimensions 2·25 square inches for the base. Barlow has apparently understood Mr. Rennie in the same way. On this latter area the above numbers are computed. On the supposition of a *four-inch base* they would stand as follows :—

No. 1. gave per sq. inch	5445 lbs.	No. 4. gave per sq. inch	4981 lbs.
" 2. " "	5185 "	" 5. " "	4338 "
" 3. " "	5152 "	" 6. " "	4178 "

These numbers change the relative values but they do not alter the position of the "alum limestone," which stands, as proved by Dr. Page, far below all the limestones and marbles, tested by Mr. Rennie, whether the latter were in 1, 1½ or 2-inch cubes.

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* See below some account of other granites of Normandy, tried in two-inch cubes by Rondelet.

† Transactions Royal Society, 1818.

5. *Experiments by Mr. Rennie on granites, tested in* 1½ *inch cubes.*

		Lbs. per sq. inch.	Relative value.
1.	Aberdeen blue granite, . . .	10,913	467
2.	Peterhead hard close grained granite, .	8,282	354
3.	Cornish granite, ...	6,356	272
[4.	*Alum limestone*, as above, . . .	2,334	100]

6. *Mr. Rennie's experiments on sandstones.*

		Lbs. per sq. inch.	Relative value.
1.	Very hard freestone (1½-inch cubes), .	9446	404
2.	Dundee sandstone, breccia, do. . .	6630	284
3.	Bramley falls sandstone near Leeds, do. .	6063	259
4.	Craigleith white freestone, do. . .	5487	234
5.	Portland stone, do.	4570	195
6.	Killaly white freestone, do. . . .	4561	195
7.	Derby grit red friable sandstone, average of two varieties, do.	3743	160
8.	Portland stone in a 2-inch cube, . .	3729	159
[9.	*Alum limestone*, as before, . . .	2334	100]

Note.—The weakest of the above sandstones is 27 per cent. stronger than the strongest specimen of the "alum limestone" tried by Dr. Page.

7. *Experiments by Messrs. Daniel and Wheatstone*, on the magnesian limestone of Yorkshire, Derbyshire and Nottinghamshire in England, employed in building the new Houses of Parliament.* Tested in two-inch cubes, in duplicate.

		Lbs. per sq. inch.	Relative value.
1.	Stone of Kiveton, ...	10,695	458
2.	" Stone-ends, . . .	9,209	394
3.	" Bolsover Moor, . . .	8,288	355
4.	" Kiveton, 2d variety, . .	6,163	284
5.	" Norfall, ...	5,879	252
6.	" Steetley, yellow variety, .	5,171	221
7.	" Steetley, white do. . .	3,192	136
[8.	*Alum limestone of Maryland*, as before,	2,334	100]

Note.—The average strength of the seven varieties of stone above compared is exactly three times as great as that of the "alum limestone."

The stone used for the houses of Parliament is described as standing, in its natural site, high above the ground, in large masses or perpendicular walls, with its smooth, bleached, time-worn surface, discolored only by a few lichens with a little moss or ivy,—facts clearly indicating its strength and durability.

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* See "Lithology, or observations on stone used for building," by C. H. Smith, p. 22.

8. *Experiments on Marbles, made in France by Rondelet, Gauthey, Sufflot and Perronet,** on two inch cubes, the weights and measures being reduced to English to conform to the other series.

		Lbs. per. sq. inch.	Relative val.
1.	Black marble of Flanders, . .	11,218	480
2.	Cervelas marble of Flanders, .	5,738	245
3.	White Statuary marble, . .	4,652	199
4.	Blue Turquin marble, . . .	4,328	185
5.	Veined white marble, . . .	4,241	181
6.	Veined white marble called Pauf, .	3,701	158
[7.	*Alum limestone of Md., as above,*	2,334	100]

Note.—With the exception of the first of the above trials the French experiments conform pretty nearly with those of Mr. Rennie on similar materials supposing the numbers given by the latter were obtained from two inch cubes; but they fall far below his results, admitting, with Tredgold, that his blocks were $1\frac{1}{2}$ inch cubes. Gregory appears to have understood that all Rennie's experiments were made on $1\frac{1}{2}$ inch cubes unless otherwise expressly stated.

9. *Experiments of Rondelet and other French experimenters on two-inch cubes of granite.*

		Lbs. per. sq. inch.	Relative value.
1.	Oriental rose granite, . .	12,518	536
2.	Granite of Normandy called *Champ du Bout,* . .	11,628	498
3.	Granite of Normandy called *Gallicien,*	9,987	428
4.	Granite of Bretagne, . .	9,303	398
5.	Green granite of Vosges, .	8,798	376
6.	Beola granite used in Milan, .	6,603	282
7.	Grey granite of Vosges, . .	6,020	257
[8.	*Alum limestone of Maryland,*	2,334	100]

The average relative value of the seven granites above cited is 396, or almost four times that of the "alum stone."

10. *Experiments on stones used in the construction of various ancient edifices*, reported by Rondelet,—size two inch cubes.

		Lbs. per. sq. inch.	Relative value.
1.	Caserté stone of Italy, . .	8,584	363
2.	Stone of Istria used by Palladio, Sancovino and Scamozze in the edifices of Venice and Vicenze,	7,395	316
3.	Fourneaux stone, pillars of All Saints Church at Angers, . .	6,317	270

* Traité theorique et pratique de l'art de bâtir. Par Jean Rondelet, tom. i. p. 211–214.

	Lbs. per sq. inch.	Relative value.
4. Grey stone of Florence, . .	6,096	261
5. Stone of the bridge of St. Maxence,	5,404	231
6. Travertin, material of ancient Roman buildings, ...	4,301	183
7. Bagneaux stone, columns of the Pantheon, Paris, . . .	3,484	149
8. Stone of the temple of Paestum,	3,258	130
[9. *Alum limestone, Maryland,* .	2,334	100·]

The average relative value of these ancient building stones is 238.

11. *Experiments on two-inch cubes of Basalt and Porphyry, by Gauthey and Rondelet*, reported by the latter in the work above cited.

	Lbs. per sq. inch, (Eng.)	Relative value.
1. Basalt of Auvergne, . .	29,549	1266
2. Porphyry, . . .	28,455	1219
3. Swedish basalt, . . .	27,196	1165
4. Basalt of Auvergne, 2d variety,	25,172	1078
5. do. do. 3d variety,	16,416	703
[6. *Alum limestone,* . .	2,334	100]

The average relative value of the basalts and porphyries is 1086.

12. *Experiments on the alum limestone of Maryland* in blocks of other dimensions than two inch cubes, published by Mr. Dougherty, the Superintendent of the Washington National Monument, as having been made at the Navy Yard, Washington.

	Per square inch of base.	Average.
1. A 1-inch cube (1 sq. inch base),	2000	
2. Another block of the same size, do.	2000	Expt. 1 and 2,—2000
3. A cube of $3\frac{1}{2}$ inches on a side, ($12\frac{1}{4}$ base,)	3265	
4. Another cube of same size, do.	3765	Expt. 3 and 4,—3515
5. A slab $4\frac{3}{4}$ inches square, 2 inches thick, (22·56 base,)	5629	
6. do. $4\frac{3}{4}$ square, $4\frac{5}{8}$ inches high, do.	2659	
7. A 4-inch cube, (16 inch base,)	5687	Expt. 5 and 7,—5658

The 6th experiment is alledged to have been made on a block of unequal thickness and therefore not to give a fair result.

The first two of the above experiments give results considerably below the average of Dr. Page's trials on two-inch cubes. The only standard with which we can at present compare them, is the one inch cube of Italian veined marble tried by Mr. Rennie, which gave 3216·lbs. per square inch. Their relative values, by this comparison, are 100 and 160. Comparing the three averages above given, there is an evident increase of strength per square inch of base, dependent apparently in some measure on the increased size of the specimens.

We are furnished by the paper of Mr. W. Wyatt of England, with a considerable series of experiments on marbles, granites,

and sandstones, tested in cubes of about the same size as the largest of those above given. His investigations were made with the aid of the hydraulic press of Messrs. Bramah & Sons, and in this respect also appear to be comparable with those, made on the alum limestone in large blocks. Each of his results is the mean of two trials*.

13. *Mr. Wyatt's experiments on marbles, in blocks of larger size than 2-inch cubes.*

	Lbs. pr. sq. inch.	Rel. value.
1. Ravaccioni marble, (blocks $4\frac{1}{2}\times4$ inches base), . . .	9632	172
2. Veined marble (" $4\frac{1}{2}\times4$ " . . .	9251	163
[3. *Alum limestone in* 4, *and in* $4\frac{3}{4}$ *inch cubes* (average), .	5658	100]

From the above and the preceding series of trials, it appears that the "*alum limestone*" falls very far below Italian marble, whether tested in 1-inch, 2-inch, or 4-inch cubes, and whether crushed under a hydraulic press, or any of the other carefully constructed machines which have been employed for the purpose in France and England. Compared with every other good marble and limestone, its inferiority of strength, when the size of cubes was the same, appears still more remarkable.

14. *Mr. Wyatt's experiments on granites tested in cubes of* 4 *inches on a side, or in blocks of which the base measured* 4·5 *by* 4 *inches.*

	Lbs. pr. sq. inch.	Rel. value.
1. Herm granite, (4-inch cubes), . . .	14,873	262
2. Heytor do. do. . . .	13,865	245
3. Dartmoor granite, do. . . .	12,275	217
4. Peterhead red do. (4·5 × 4 inch base), .	10,931	193
5. Aberdeen blue do. (4·25 × 4 do.) . .	10,393	183
6. Peterhead blue gray do. (4·5 × 4 do.) .	9,766	172
7. Penryn granite, (4·5 × 4 do.) . .	7,728	136
[8. *Alum limestone*, (in 4 and in $4\frac{3}{4}$ cubes), .	5,658	100]

15. *Mr. Wyatt's experiments on sandstones*, tested in cubes of $5\frac{1}{2}$ and 6 inches on a side.

	Lbs. pr. sq. inch.	Rel. val.
1. Yorkshire Cromwell stone (5·5 inch cubes)	8,825	156
2. Craigleith stone (6 inch cubes), . .	6,652	117
3. Humbie stone do. . . .	4,614	81
4. Whitby sandstone do. . . .	2,374	41
[5. *Alum limestone* (4 and 4·75 cubes), . .	5,658	100]

The average strength of the above four sandstones is almost identical with that of the *alumstone*, as given by these experiments. Had the cubes been 4 instead of 6 inches, the comparison might probably have been more favorable to the alumstone. Its true position in the scale of strength, among building stones,

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* See Transactions of the Society of Civil Engineers, vol. i, p. 235.

as proved both by Dr. Page and Mr. Wyatt, is among the *sandstones*, not among granites, marbles or compact limestones.

16. In addition to the foregoing comparisons, the writer is enabled to add two experiments of his own on the Quincy syenite, the stone of which the Bunker Hill Monument is built. These experiments were made July 28, 1843.

	Lbs. pr. sq. inch.	Rel. value.
1. A 1·5 inch cube (2·25. sq. inch base), bore . . .	15,929	682
2. A block having a base 2·5×1·15=2·87 sq. inches and a length of 5·25 inches, proved endwise, bore . .	12,390	530
[3. *Alum limestone*—Dr. Page's trials on 2 inch cubes, .	2,334	100]

Note.—The block proved by compressing it endwise was not crushed, but only splintered or slightly "spalled" along the corners. This was done at two successive applications of the same compressing force. The 1·5 inch cube was crushed with the force above given.

From these experiments it appears that the Bunker Hill Monument stone is possessed of a strength intermediate between *Oriental rose granite*, and *Auvergne basalt*, as given by M. Rondelet.

That a coarse, loosely aggregated rock like the alumstone, is far inferior in strength to rocks of the same chemical constitution and specific gravity but of fine texture, was long since proved by Rondelet. We may cite one or two of his proofs and add by way of comparison, two others derived from the preceding sections of this paper.

17. *Experiments on coarse, and on fine-grained stones of the same class.* Specimens tried in two-inch cubes.

1.	Roussard stone, *coarse* grained, ...	3957
	Choin de Villeburg, *fine* grained, ...	8300
2.	Saillan court stone, *coarse* grain, ...	2062
	Stones of Passy and Vaugirard, *fine* grain, ...	4484
3.	Symington's *coarse alum limestone*, (11 trials by Dr. Page,) .	2334
	Symington's fine grain marble, (2 do. do. . .	4484
4.	*Alum limestone*, highest of Dr. Page's results, . . .	2968
	Fine grain marble, highest result by Mr. Mills, ...	6344

The average strength of the four coarse-grained stones is 2830, that of the four fine grained ones, 5982. The ratio of these numbers is 100 to 211.

Arranging the several kinds of stone in the order of their relative values as determined by their power to resist crushing, and placing against each the number of square inches on the base of the specimens tried, with the name of the experimenter, we have the following rank, as indicated by a comparison with the *alum limestone* used in casing the Washington National monument, the strength of which is taken as 100.

No.	Name of stone.	Area of base of specimens in sq. inches.	Name of experimenter.	Rel. val. Alumstone = 100.
1.	Basalt of Auvergne,	4	Rondelet,	1266
2.	Porphyry,	4	do.	1219
3.	Swedish basalt,	4	do.	1165
4.	Auvergne basalt, 2d variety,	4	do.	1098
5.	do. do. 3d variety,	4	do.	703
6.	Quincy syenite, 1½ inch cube,	2·25	Johnson,	682
7.	Oriental rose granite,	4	Rondelet,	536
8.	Quincy syenite, long block,	2·87	Johnson,	530
9.	Granite of Normandy. *Champ du Bout*,	4	Rondelet,	498
10.	Black marble of Flanders,	4	do.	480
11.	Aberdeen blue granite,	2·25 (?)	Rennie,	467
12.	Kiveton dolomite,	4	Daniel & Wheatstone.	458
13.	Granite of Normandy, *Gallicien*,	4	Rondelet,	428
14.	White Italian veined marble,	2·25 (?)	Rennie,	414
15.	Very hard freestone,	2·25	do.	404
16.	Granite of Bretagne,	4	Rondelet,	398
17.	Brabant black marble,	2·25 (?)	Rennie,	395
18.	Dolomite from Stonends,	4	Daniel & Wheatstone.	394
19.	Purbeck stone,	2·25 (?)	Rennie,	392
20.	Compact black limestone of Limerick,	2·25 (?)	do.	379
21.	Green granite of Vosges,	4	Rondelet,	376
22.	Caserté stone of Italy,	4	do.	363
23.	Bolsover Moor dolomite,	4	Daniel & Wheatstone.	355
24.	Peterhead close-grained granite,	2·25 (?)	Rennie,	354
25.	Compact limestone,	2·25 (?)	do.	330
26.	Istria stone,	4	Rondelet,	316
27.	Devonshire red marble,	2·25 (?)	Rennie,	308
28.	Kiveton dolomite, 2d variety,	4	Daniel & Wheatstone.	284
29.	Dundee sandstone,	2·25	Rennie,	284
30.	Beola granite, Milan,	4	Rondelet,	282
31.	Cornish granite,	2·25	Rennie,	272
32.	Symington's fine-grained stone,	4	Mills,	271
33.	Fourneaux stone, Angers,	4	Rondelet,	270
34.	Baltimore granite,	4	Mills,	267
35.	Herm granite,	16	Wyatt,	262
36.	Greystone of Florence,	4	Rondelet,	261
37.	Brainley Falls sandstone, Leeds,	2·25	Rennie,	259
38.	Statuary marble not veined,	2·25	do.	259
39.	Grey granite of Vosges,	4	Rondelet,	257
40.	Norfall dolomite,	4	Daniel & Wheatstone.	252
41.	Heytor granite,	16	Wyatt,	245
42.	Cervelas marble of Flanders,	4	Rondelet,	245
43.	Craigleith white freestone,	2·25	Rennie,	234
44.	Bridge of St. Maxence stone,	4	Rondelet,	231
45.	Steetley yellow dolomite,	4	Daniel & Wheatstone.	221
46.	Dartmoor granite,	16	Wyatt,	217
47.	White statuary marble,	4	Rondelet,	199
48.	Portland stone,	2·25	Rennie,	195
49.	Killaly white freestone,	2·25	do.	195
50.	Peterhead red granite,	18	Wyatt,	193
51.	Symington's Maryland fine-grained stone,	4	Page,	192
52.	Blue Turquin marble,	4	Rondelet,	185
53.	Travertin of Ancient Rome,	4	do.	183
54.	Aberdeen blue granite,	17·5	Wyatt,	183
55.	Veined white marble,	4	Rondelet,	181
56.	Peterhead blue grey granite,	18	Wyatt,	172
57.	Ravaccioni marble,	18	do.	172
58.	East Chester marble, N. Y.,	4	Page,	171
59.	Veined marble,	18	Wyatt,	163

TABLE CONTINUED.

No.	Name of stone.	Area of base of specimens in sq. inches.	Name of experimenter.	Rel. val. Alum-stone = 100.
60.	Metamorphic blue Potomac stone, ...	2·25	Mills, ...	160
61.	Derby grit, friable sandstone, ...	2·25	Rennie, ...	160
62.	Portland stone, ...	4	do.	159
63.	Veined white marble, (Pauf,)	4	Rondelet, ...	158
64.	Yorkshire Cromwell stone, ...	30·25	Wyatt, ...	156
65.	Bagneaux stone, (Pantheon at Paris,)	4	Rondelet, ...	149
66.	Granite of Port Deposite, ...	4	Mills, ...	139
67.	White veined Italian marble, ...	1	Rennie, ...	137
68.	Steetley white dolomite, ...	4	Daniel & Wheatst'ne	136
69.	Penryn granite, ...	18	Wyatt, ...	136
70.	Italian marble.	4	Page.	135
71.	Temple of Paestum stone, ...	4	Rondelet, ...	130
72.	Patapsco granite, ...	4	Page, ...	118
73.	Craigleith sandstone, ...	36	Wyatt, ...	117
74.	Seneca sandstone, Smithsonian Institute, .	4	Page, ...	115
75.	Granite of Normandy, ...	4	Mills, ...	112
76.	*Alum limestone*, (Wash'gton Nat'nal. Mon't.)	4	Page, ...	100
77.	Stockbridge marble, ...	4	do.	96
78.	York road brown sandstone, ...	4	do.	91
79.	Humbie sandstone, ...	36	Wyatt, ...	81
80.	Aquia Creek (Patent Office) sandstone, ..	4	Page, ...	71
81.	Whitby sandstone, ...	36	Wyatt, ...	41

The wide discrepancy already noted between the results obtained in experimenting on the alum limestone, in which the pressure required for crushing varied from 910 pounds to 5687 pounds per square inch of the area of the base, must be explained either on one or the other of three suppositions; 1st, that the strength of different specimens of the rock is thus variable, and that consequently no certain reliance could be placed on its powers of resistance; or 2nd, that the experimenting or the machine with which it was conducted was faulty; or 3rd, that the resistance to crushing for a unit of area at the base, increases in some ratio with the number of units composing that area, that is, with the actual area of the base. The experiments published by Mr. Dougherty show discrepancies nearly as wide as those previously made by Dr. Page, beginning however with 2000 pounds on a one-inch cube, and ending with 5687 pounds per square inch on a four-inch cube, instead of beginning with 910 pounds and ending with 2968 pounds on two-inch cubes.

With a view to trace some relation, if such exist, between the increase of area of base and the power of resistance of cubes of granular rocks and other materials, the writer has proposed a series of trials on several stones, in cubes of different sizes from one to six inches on a side, all those of the same kind of stone to be taken from the same block and accurately reduced to the respective dimensions. At present the following comparisons *seem* to point to a direct relation between the power of resistance of the cube and the product of the ***area of the base multiplied into the cube root of that area.***

1. The one-inch cubes of alum limestone gave Mr. Dougherty two thousand pounds, and the 4·75 inch cube, having 22·56 square inches on the base, gave 5629 pounds per square inch. In comparing these with the cube roots of the areas of base we have $\sqrt[3]{1} : \sqrt[3]{22{\cdot}56} :: 2000 : 5652$ or the calculated exceeds the experimental result by only twenty three pounds, or 0·4 per cent.

2. A two-inch cube of the alumstone in Dr. Page's third experiment gave per square inch of base 2281 pounds, and a $3\frac{1}{2}$ inch cube in Mr. Dougherty's third experiment, gave 3265 pounds per square inch. Comparing these we have $\sqrt[3]{4} : \sqrt[3]{12{\cdot}25} :: 2281 : 3312$ showing that the calculated exceeds the experimental result by 47 pounds or about one and a half per cent.

3. The seventh experiment of Dr. Page gave 2625, and the fourth of Mr. Dougherty gave 3765, consequently $\sqrt[3]{4} : \sqrt[3]{12{\cdot}25} :: 2625 : 3812$, in which the calculated exceeds the experimental by forty-two pounds, or $1\frac{1}{16}$ per cent.

4. Mr. Dougherty's first and second experiments on one inch cubes gave 2000 pounds, and Dr. Page's eleventh experiment on two-inch cubes gave 2968. Hence $\sqrt[3]{1} : \sqrt[3]{4} : 2000 : 3156$ where calculation exceeds experiment by two hundred and seven pounds, or 6·9 per cent.

5. Comparing Dr. Page's eleventh experiment with Mr. Dougherty's fifth, in which a block $4\frac{3}{4}$ inches on a side bore 5629 pounds per square inch, we have $\sqrt[3]{4} : \sqrt[3]{22{\cdot}56} :: 2968 : 5283$, in which calculation falls short of experiment by 346 pounds or about 6 per cent.

6. Mr. Rennie's eighth trial on marbles, showed that a one inch cube of white Italian marble bore 3216, and M. Rondelet on a two inch cube of the same, obtained per square inch, 4651 pounds. Hence $\sqrt[3]{1} : \sqrt[3]{4} :: 3216 : 5106$, the calculated exceeding the experimental result by 455 pounds, or nearly 9 per cent.

7. By our reading of Mr. Rennie's memoir, he obtained from a two inch cube of Italian veined marble, 5445 pounds per square inch, and Mr. Wyatt obtained from a $4\frac{1}{2}$ by 4 inch block, 9251 pounds. Here, $\sqrt[3]{4} : \sqrt[3]{18} :: 5445 : 8990$ differing in defect from the experimental result by 261 pounds, or less than 3 per cent.

8. If Mr. Rennie's experiment on Aberdeen granite was, as we suppose, also on a two inch cube, its strength per square inch was 6139 pounds, and as Mr. Wyatt obtained from Aberdeen granite, when tried in blocks $4\frac{1}{2} \times 4$ inches on the base, a strength of 10,393 pounds, we have $\sqrt[3]{4} : \sqrt[3]{18} :: 6139 : 10{\cdot}130$ where the calculated falls short of the experimental result by 263 pounds $= 2\frac{1}{2}$ per cent.

9. Mr. Rennie proved Cornish granite in one and a half inch cubes to have a strength per square inch of 6356, and Mr. Wyatt on a four inch cube of Dartmoor granite, obtained 12,275 pounds.

Now $\sqrt[3]{2{\cdot}25} : \sqrt[3]{16} :: 6356 : 12{,}420$ making the calculated to exceed the experimental result by 145 pounds or $1\frac{1}{11}$ per cent.

10. Mr. Rennie tried five blocks of cast iron of $\frac{1}{8}$th inch square base and $\frac{1}{8}$th to $\frac{2}{8}$th high and found the crushing force 1710 pounds per one-eighth. He also tried thirteen cubes of $\frac{1}{4}$th inch, and found the average 2600 pounds per one-eighth inch base. In this case $\sqrt[3]{1} : \sqrt[3]{4} :: 1710 : 2712$, showing the calculated to exceed the experimental result by 112 pounds, or about 4 per cent.

It is not alledged that these ten cases conclusively establish the law, but they seem to afford a pretty strong presumption in its favor; and though it is true that these cases are for want of certainty as to the perfect similarity of specimens compared, liable to some objection, yet they appear to warrant a series of experiments of the kind above proposed. Should the law not be thereby confirmed, one of the other explanations of the discrepancies in the strength of "alum limestone" must be resorted to.

ART. II.—*On the Law of the Induction of an Electric Current upon itself when developed in a straight prismatic conductor, and of discharges of Machine Electricity through straight wires;** by J. H. LANE, of the U. S. Patent Office.

THE original discovery of the induction of electric currents was made by Prof. Faraday, about twenty years since. Prof. Henry followed up the subject in the very elegant and elaborate series of experiments, detailed in his "Contributions to Electricity and Magnetism," published in the Journal of Science for 1840 and 1841, and the full and able discussion of those experiments in the same papers presents the most complete elucidation of the laws of the induction of electric currents that has yet appeared. Prof. Henry added the interesting discovery of the induction of an electric current upon itself, and showed that this too could be referred to the single principle of the inductive action of the primary current upon a neighboring conductor. The simple laws to which he refers all the phenomena yet observed are laid down by him in these three propositions.

"1. During the time a galvanic current is increasing in quantity in a conductor, it induces or tends to induce, a current in an adjoining parallel conductor, in an opposite direction to itself.

"2. During the continuance of the primary current in full quantity, no inductive action is exerted.

"3. But when the current begins to decline in quantity, and during the whole time of its diminishing, an induced current

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* The principal results contained in this paper were read before the National Institute at Washington, and subsequently communicated through a scientific friend to the American Association at their meeting in New Haven, in August, 1850.

is produced in an opposite direction to the induced current at the beginning of the primary current."

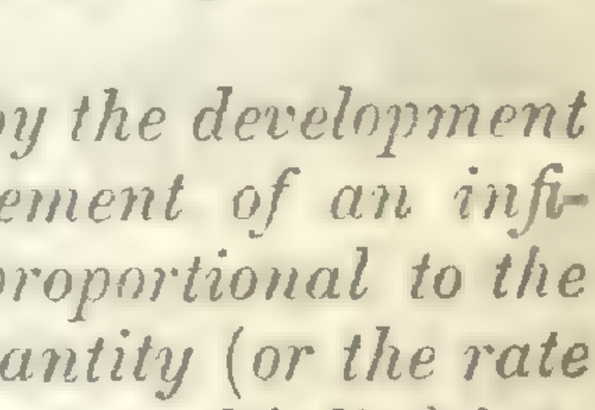
My purpose in this paper is to present certain deductions from these laws in reference to the induction upon itself of an initial electric current moving in a straight conductor. In arriving at these deductions however it will be necessary to add to the laws above enunciated, one or two farther hypotheses as to the variation of the inductive force at different distances and in different positions of the primary current, which hypotheses are however too plainly suggested by the analogies furnished by other well established laws of electricity to admit of very serious doubt. Still they cannot be regarded as established by direct experiment, but are open to future investigation, and if the few results I venture now to make public shall be found to afford any facility to such an investigation, one object of this paper will have been attained.* The very simple and sufficiently elegant analytical result arrived at in the solution of what at first seemed a difficult problem, has also furnished an additional motive with me for its publication.

1. Prof. Henry's laws, with the hypotheses assumed as the basis of the present investigation, may be summed up in the following enunciation.

The inductive force exerted at a given point by the development of an electric current in an infinitely short element of an infinitely attenuated conducting wire, is directly proportional to the rapidity with which the current increases in quantity (or the rate of development) *and to the length of the element multiplied into the natural sine of the angle it makes with the line drawn from it to the given point, and inversely proportional to the square of that line; and in a direction at right angles to the same in the plane of the element, but contrary to the direction of the developed or primary current.*

Let *ab*, fig. 1, be an infinitely short element of an electric current flowing with increasing rapidity in the direction of the arrow, and let *c* be any point within the space of its sensible action: join *bc* and draw the perpendicular *af*. We have the analogy of the dynamical action of galvanic currents for believing that the inductive effect of the elementary current will be the same whether it move through the straight line *ab* or through the route *afb*. But in the latter case it is nearly certain that the part *fb* will have no effect at *c* in any direction transverse to the line *cb*, there

1.



* The most serious question, it appears to me, that can be raised in regard to these deductions respecting the nature of the induction of a current upon itself, is whether the action designated by that name is really due, as Prof. Henry believes, to inductive action at a distance only, or may not be partly due to a different species of action more strictly analogous to inertia in ponderable matter. The former supposition is more in accordance with the simplicity of nature's operations, and at present there is not, so far as I am aware, any special reason to doubt its correctness. Nevertheless, I hope to be able to settle the question hereafter by experiment.

being no reason why there should be more of such action in one direction than another (i. e., on one side of *cb* rather than another) except on the extreme supposition of the inductive action being dependent on or connected with the influence of surrounding bodies which there is not the slightest reason to suspect; if, therefore, *fb* exerted any influence at all we should from the nature of the case expect to find it in the direction of *cb* only, and there is not the first fact yet known that indicates any action in that direction. In reference to the dynamic action of the current after it is established we know with all reasonable assurance that *fb* is not felt at *c*. There remains then the influence of the part $af = ab \sin abc$, and we may assume, also, from the analogy of the known law of the dynamic action, that its action is directly proportional to its length and inversely proportional to cb^2 and also directly proportional to the rate of development of the current in *afb* or in *ab*. All experiments moreover indicate that the direction of the inductive force is at right angles to *cb* and in the plane *abc*.

2. It may be well to state before going farther that in the use of the term inductive force, I have no reference whatever to the secondary current that may result from the exertion of that force. Whenever an electric current is generated in a conductor an inductive force is exerted at any point in the neighborhood, and if the medium in which it is exerted be a conductor of electricity a current will be produced; if not no current can take place, but the force does not the less really exist, and is as really measurable as a mechanical force though it would be too much to assert that it is a mechanical force. It is of course to be estimated like every electro-motive force without reference to the transverse extent of the elementary space in which it is exerted, but solely with reference to its longitudinal extent in the direction of the force, in the same manner as we estimate the intensity of the pressure of a column of water according to its perpendicular height alone.

3. Returning now to the fundamental law just premised let q represent the quantity of current flowing in *ab* at the end of the time t from a given instant: $\frac{\mathrm{d}q}{\mathrm{d}t}$ will then represent the rate of development of the current. Also let the distance $cb = D$ and let $l =$ the length of the electric conductor of which *ab* is an element so that $ab = \mathrm{d}l$ and let the angle $abc = \theta$. Then the inductive force exerted by *ab* at *c* in the direction as above stated of *cd* will be proportional to

$$\frac{\mathrm{d}q}{\mathrm{d}t}\,\frac{\sin\theta\,\mathrm{d}l}{D^2}$$

This formula will embrace the 2d and 3d of the above quoted enunciations of Prof. Henry, if $\mathrm{d}q = 0$ for a constant current and be considered negative when the current is diminishing in quantity. If we wish to estimate the inductive force in the direction

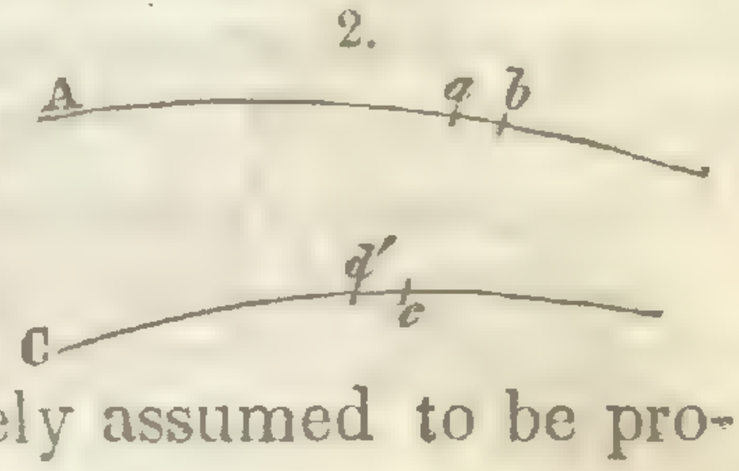
of a line cd' which makes with cd the angle τ either in the plane abc or out of it, we must resolve the force in the direction of cd in the same manner as any other electro-motive force or as a mechanical force, so that if M represent the whole force in the direction of cd and M' the resolved force in the direction of cd' we shall have $M' = M \cos \tau$.

Thus we shall finally have the inductive force exerted at c in the direction of cd' proportional to

$$\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\,\frac{\cos\tau \sin\theta\,\mathrm{d}\,l}{D^2}.$$

4. This regards the inductive force as exerted at a single point, but all experiments show that it accumulates along the secondary conductor in proportion to its length. Let $A\,b$, fig. 2, be the primary conductor and $c\,C$ the secondary, and let I represent the whole inductive force exerted by $A\,a$ on the whole secondary $c\,C$ of which the length $= s$. Then the whole inductive force exerted on the element $cd' = \mathrm{d}\,s$ (and which may be safely assumed to be proportional to cd') will be expressed by $\frac{\mathrm{d}\,I}{\mathrm{d}\,s}\,\mathrm{d}\,s$, and that exerted on cd' by ab will have for its expression $\frac{\mathrm{d}^2 I}{\mathrm{d}\,s\,\mathrm{d}\,l}\,\mathrm{d}\,s\,\mathrm{d}\,l$. Hence we shall have

2.



$$\text{(A)} \qquad \frac{\mathrm{d}^2 I}{\mathrm{d}\,s\,\mathrm{d}\,l} = C\,\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\,\frac{\cos\tau \sin\theta}{D^2}.$$

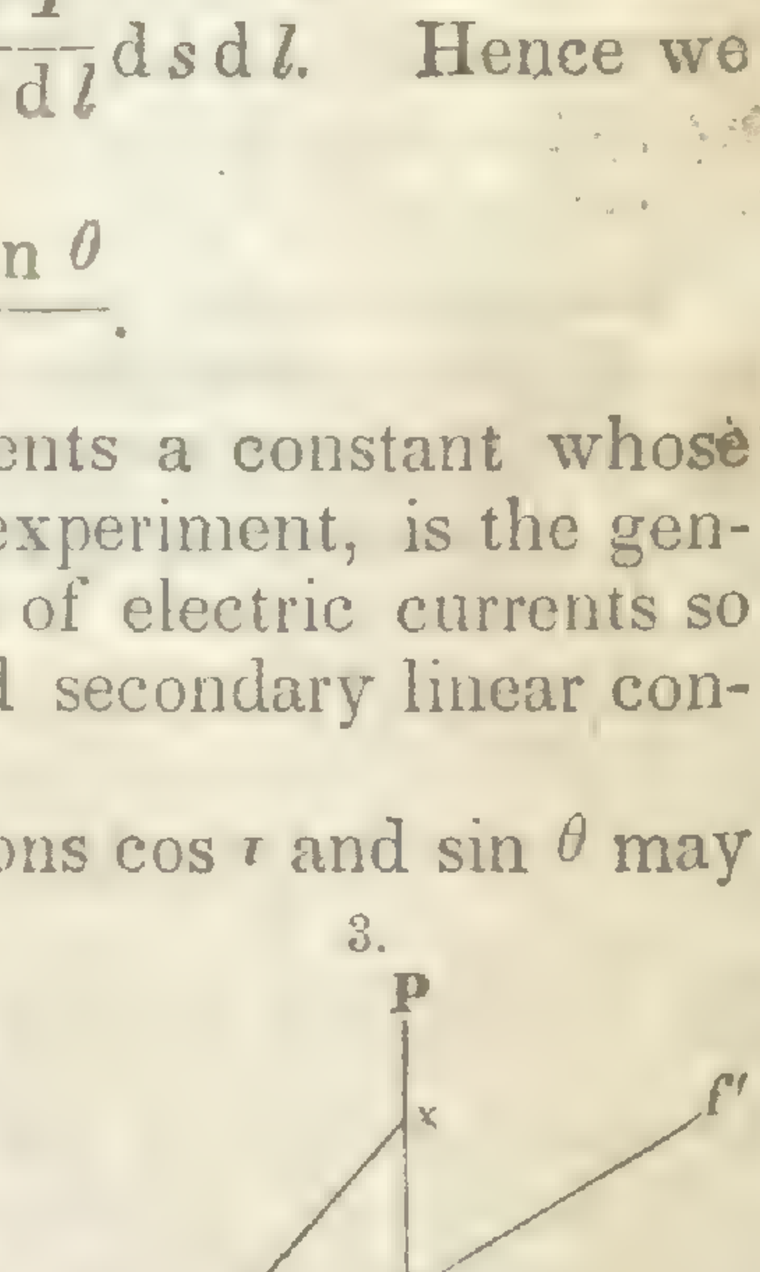
This equation then in which C represents a constant whose value has never yet been determined by experiment, is the general differential equation for the induction of electric currents so far as concerns the relation of primary and secondary linear conductors to each other.

The lines l, D, and s and circular functions $\cos\tau$ and $\sin\theta$ may readily be referred to rectangular coordinates in space, but for my present purpose this is not necessary.

5. From (A) it readily follows that,

If an electric current be developed in a straight wire of unlimited length so small that it may be regarded as a line, the force of induction in a direction parallel with the wire at any given point will be inversely as the perpendicular distance of that point from the wire.

3.



Let PN, fig. 3, be the straight conducting wire and let cd' be the given

element of space parallel to PN in which the inductive force is to be exerted, and let ab be an element of PN. Draw the perpendicular cp and let $cp=r$, and let θ' represent the angle pca, the complement of pac or θ. It being understood that cp is the origin of the angle θ' and p the origin of l, we have in applying the formula (A)

$$\tau=dcd'=\theta' \qquad l=pa=r\tan\theta'$$

$$D=ca=r\sec\theta' \qquad \mathrm{d}\,l=r\frac{\mathrm{d}\,\theta'}{\cos^2\theta'}$$

The substitution of these values in (A) gives us;

$$\frac{\mathrm{d}^2 I}{\mathrm{d}\,s\,\mathrm{d}\,l}\mathrm{d}\,l=\frac{C}{r}\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\cos^2\theta'\,\mathrm{d}\,\theta'$$

and the integration of this with reference to θ' gives us for the whole inductive force exerted in the elementary space cd' or $\mathrm{d}\,s$ in the direction of the latter by the current in pa

$$\frac{\mathrm{d}\,I}{\mathrm{d}\,s}\mathrm{d}\,s=\frac{C}{r}\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\mathrm{d}\,s\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta'$$

or still dividing by $\mathrm{d}\,s$ we shall retain in what follows only the coëfficient $\frac{\mathrm{d}\,I}{\mathrm{d}\,s}$ calling it the inductive force at the *point* c parallel with PN, and in the present instance therefore we have

$$\text{(B)}\qquad \frac{\mathrm{d}\,I}{\mathrm{d}\,s}=\frac{C}{r}\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta'$$

in which if the limits of integration be constant the value of the second member is inversely as r. Hence if any two radial lines as cf, cf' be drawn, the induction in the *direction* cd' due to that part of the conductor PN cut off by those radial lines is inversely proportional to the distance cp.

6. Carrying out the integration indicated in the preceding formula we have

$$\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta'=\tfrac{1}{2}(\eta'-\eta)+\tfrac{1}{4}(\sin 2\eta'-\sin 2\eta)$$

and if, by including a great length of conductor on both sides of p the limits η and η' be made closely to approach the values of $+\frac{1}{2}\pi$ and $-\frac{1}{2}\pi$ so that $\eta=-(\frac{1}{2}\pi-h)$ and $\eta'=+(\frac{1}{2}\pi-h')$ where h and h' are very small arcs, we have

$$\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta=\tfrac{1}{2}\pi-\tfrac{1}{4}(2h'-\sin 2h')-\tfrac{1}{4}(2h-\sin 2h)$$

which expression differs from $\frac{1}{2}\pi$ only by a small quantity of the third order, so that if the conductor be extended till it subtends an angle *wcx* closely approaching 180°, the inductive force due to all beyond that limit will be insensible* in practice, the value of $f\cos^2\theta' \,\mathrm{d}\theta'$ remaining nearly constant. Hence, what was stated of that part of the conductor included in a fixed angle *fcf'*, may be affirmed also of a determinate length *wx* of the conductor so long as the distance *cp* is very small compared with either *px* or *pw*, that its inductive action parallel to itself is inversely as the distance, and this action is expressed thus

$$\text{(C)} \qquad \frac{dI}{\mathrm{d}s} = \tfrac{1}{2}\frac{C}{r}\frac{\mathrm{d}q}{\mathrm{d}t}\pi.$$

7. The expression for the induction at right angles to *c d'* or in the direction of *pc* will be identical with that for the induction in the direction of *cd'*, except that instead of the circular function

$$\int_{\eta}^{\eta'} \cos^2\theta' \,\mathrm{d}\,\theta'$$ in equation (B) we shall have

$$\int_{\eta}^{\eta'} \sin\theta' \cos\theta' \,\mathrm{d}\,\theta' = \tfrac{1}{2}(\sin^2\eta' - \sin^2\eta)$$

which is necessarily zero or insensible when the limits η and η' are equal and of contrary signs or when each differs very little from $\frac{1}{2}\pi$, whence it follows that for any portion of the conductor bisected in the point *p*, or for any portion extending to a very great distance on both sides of *p*, the induction in the direction of *pc* is nothing or insensible. The phenomenon known in machine electricity as the lateral discharge, cannot be considered at variance with this statement, as that is readily explained without reference to the existence of an inductive force in *that direction* of the kind now under consideration.

Induction of an electric current upon itself, when developed in a straight prismatic conductor of great length.

8. I have already stated that Prof. Henry was the discoverer of the induction of a current upon itself, and that he was the first to refer it to the primary law of induction at a distance. A conductor of an electric or galvanic current may be regarded as constituted of a bundle of numerous very attenuated fibres, each conducting part of the current, and feeling, during the development, the inductive influence of the currents developed in all the other fibres.

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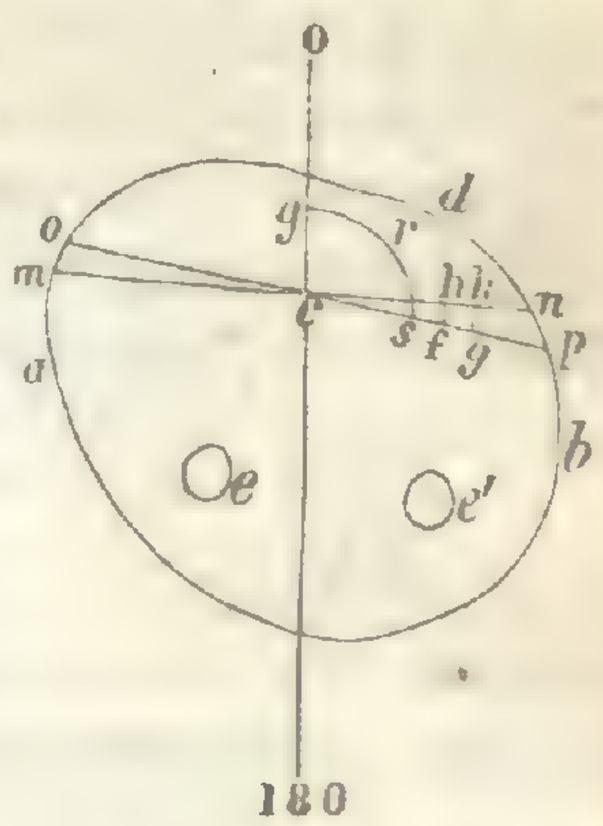
* Similarly it may readily be shown that if the current be returned into itself through a return circuit passing everywhere at a great distance the inductive force due to the return circuit will be insignificant.

Let *abd*, fig. 4, represent a cross section taken at a distance from either extremity of a prismatic conductor of great length in which a current of electricity is being developed, and let the conductor be supposed to be divided longitudinally into infinitely small elementary prisms or fibres. If a bundle of these fibres be taken whose cross section is the figure *e*, the portion of current conducted by the bundle may be distinguished as the current ***through the figure or area e.*** We shall first suppose the development of current to be equally rapid through all parts of the cross section of the conductor (i. e., through any two spaces *e*, *e′*, of equal area), and compare the magnitudes of the inductive forces at different points of the cross section *abd*.

4.



9. Let *c* be the point at which the inductive force is to be estimated. Through *c* draw the straight lines *mcn* and *ocp*, making with each other an infinitely small angle $ncp = \mathrm{d}\varphi$. Let *fg* be an infinitely short line taken in any part of *cp* or *oc* and draw the perpendiculars *fh* and *gk*. The inductive force exerted at *c* by the current through the area *fk* is given by formula (C). If Q represent the quantity of current passing at a given instant through a unit of sectional area, the quantity q passing through *fk* will be

$$q = Q \times \text{ area } fk \text{ and } \frac{\mathrm{d}q}{\mathrm{d}t} = \text{ area } fk \times \frac{\mathrm{d}Q}{\mathrm{d}t}.$$

Also $cf = r$, $fg = \mathrm{d}r$, $fh = r\,\mathrm{d}\varphi$, area $fk = r\,\mathrm{d}r\,\mathrm{d}\varphi$, and if we denote the whole inductive force exerted at *c*, in a fibre of the length s, by the current through any portion of *cgrs* of the cross section, by P, we shall have $I = \dfrac{\mathrm{d}^2 P}{\mathrm{d}r\,\mathrm{d}\varphi}\,\mathrm{d}r\,\mathrm{d}\varphi$.

Substituting these values in (C), we have for the inductive force exerted at *c* by the current through *fk*

$$\text{(D)} \qquad \frac{\mathrm{d}I}{\mathrm{d}s} = \frac{\mathrm{d}^3 P}{\mathrm{d}s\,\mathrm{d}r\,\mathrm{d}\varphi}\,\mathrm{d}r\,\mathrm{d}\varphi = \tfrac{1}{2} C\pi \frac{\mathrm{d}Q}{\mathrm{d}t}\,\mathrm{d}r\,\mathrm{d}\varphi.$$

As Q and consequently $\dfrac{\mathrm{d}Q}{\mathrm{d}t}$ is at present supposed to be the same for all parts of the section *abd*, it follows from (D) that the inductive force due to the current through *fk* is simply proportional to the magnitude of the elementary angle *ncp* and to the length of *fg*, independently of its distance from *c*, and that the whole force due to the current through the triangular spaces *ncp* and *mco* is

$$\text{(E)} \qquad \frac{\mathrm{d}^2 P}{\mathrm{d}s\,\mathrm{d}\varphi}\,\mathrm{d}\varphi = \tfrac{1}{2} C\pi \frac{\mathrm{d}Q}{\mathrm{d}t}\,E\,\mathrm{d}\varphi,$$

in which E represents the length of the chord mn. Now if a straight line revolve about the point c from the position 0 – 180, through a half revolution it will describe all the elementary triangles mco and pcn that make up the section abd. Therefore integrating (E) between the limits of $\varphi = o$ and $\varphi = \pi$, we have finally for the inductive force exerted at c by the whole current

$$\text{(F)}, \qquad \frac{\mathrm{d}P}{\mathrm{d}s} = \tfrac{1}{2} C \pi \frac{\mathrm{d}Q}{\mathrm{d}t} \int_o^\pi E \, \mathrm{d}\varphi,$$

10. If the rate of development $\frac{\mathrm{d}Q}{\mathrm{d}t}$ be not constant through all parts of the section abd, then $\frac{\mathrm{d}Q}{\mathrm{d}t} E$ in equations (E) and (F) must be replaced by

$$\int_{-\lambda}^{+\lambda} \frac{\mathrm{d}Q}{\mathrm{d}t} \mathrm{d}r$$

in which λ and λ' denote the values of mc and cn, and the equations (E) and (F) become

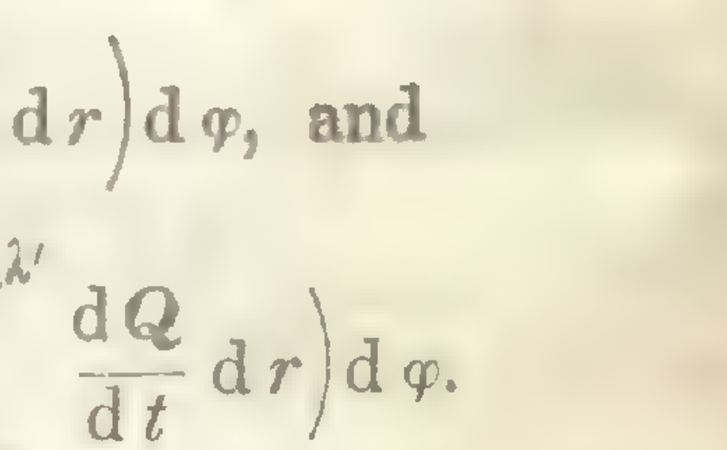
$$\text{(E')}, \qquad \frac{\mathrm{d}^2 P}{\mathrm{d}s} \mathrm{d}\varphi = \tfrac{1}{2} C \pi \left(\int_{-\lambda}^{+\lambda'} \frac{\mathrm{d}Q}{\mathrm{d}t} \mathrm{d}r \right) \mathrm{d}\varphi, \text{ and}$$

$$\text{(F')}, \qquad \frac{\mathrm{d}P}{\mathrm{d}s} = \tfrac{1}{2} C \pi \int_o^\pi \left(\int_{-\lambda}^{+\lambda'} \frac{\mathrm{d}Q}{\mathrm{d}t} \mathrm{d}r \right) \mathrm{d}\varphi.$$

Comparison of the inductive forces at the centre and surface of a long cylindrical conductor, when the development is uniformly rapid throughout its mass.

11. Let fig. 5, represent the cross section of a cylindrical conductor or wire of a great length in comparison with the diameter, which we will call $2R$, and let us suppose a current to be developed with equal rapidity through all parts of the section. Then in finding the whole inductive force at the centre c by formula (F) we have the chord E always a diameter or $= 2R$, and consequently

5.



$$\int_o^\pi E \, \mathrm{d}\varphi = 2\pi R,$$

while for the point c', the chord $c'n' = 2R \sin T c' n'$ or $E = 2R \sin \varphi$, and

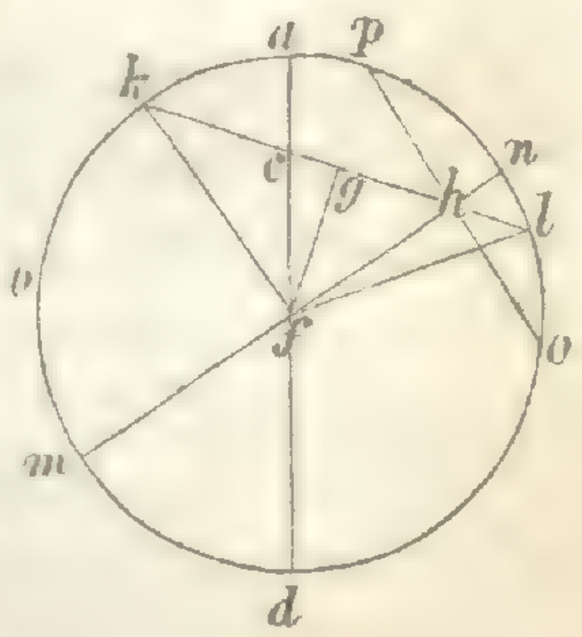
$$\int_o^\pi E \, \mathrm{d}\varphi = 2R \int_o^\pi \sin \varphi \, \mathrm{d}\varphi = 4R.$$

The inductive forces at the centre and circumference are therefore as $\pi : 2$, or as the semi-circumference of a circle to its diameter. This would lead us to expect the initial development of an electric current in a wire at the first instant of the application of an electro-motive force, acting as is usually the case with equal intensity through all parts of the cross section, to be more rapid at the surface than at the centre, for the inductive force must be exactly sufficient at every point to balance the force applied.

Equilibrium of the initial inductive forces within the mass of a straight cylindrical conductor, or law of initial development of the current through different parts of its cross section.

12. Let *abd*, fig. 6, be the cross section of a cylindrical conductor of great length, and let a current be developed in it by the application of an electro-motive force acting uniformly through all parts of the cross section. Take any point c in the diameter ad (whose distance fc from the centre we will call z), and draw the chord kcl, making with ad any angle $acl = 90° + \varphi$. Draw the perpendicular fg, and in kl take any point h and draw the straight line fh producing it to m and n and denote gh by x and the angle gfl by φ'. Following the motion of the lines fg and fl as kcl makes its motion of 180°, this angle φ' is to be taken greater or less than 90° according as φ is greater or less than 90°. Putting R for the radius of the circle, we shall have kg or $gl = R \sin \varphi'$. The rate of development $\frac{\mathrm{d}Q}{\mathrm{d}t}$ at the point h may be safely assumed to depend on the distance fh from the centre, which distance determines the value of the rectangle $mh \,.\, hn$ and consequently that of $kh \,.\, hl$ or $R^2 \sin^2 \varphi' - x^2$; $\frac{\mathrm{d}Q}{\mathrm{d}t}$ must therefore be some function of this latter quantity, or

6.



$$\frac{\mathrm{d}Q}{\mathrm{d}t} = F(R^2 \sin^2 \varphi' - x^2).$$

Substituting this value in formula (F′) and also that of $\mathrm{d}r = \mathrm{d}x$ and then replacing the limits of r by those of x, we have

$$(\mathrm{F}'') \qquad \frac{\mathrm{d}P}{\mathrm{d}s} = \tfrac{1}{2} C \pi \int_0^{\pi} \left(\int_{-R \sin \varphi'}^{+R \sin \varphi'} F(R^2 \sin^2 \varphi' - x^2)\, \mathrm{d}x \right) \mathrm{d}\varphi.$$

Our problem requires that such a form be given to the function $F(R^2 \sin^2 \varphi' - x^2)$, which we may call simply F, that the second

member of the last equation shall be independent of z or of φ'. We shall first show that this requires that

$$\int_{-R\sin\varphi'}^{+R\sin\varphi'} F\,\mathrm{d}\,x$$

be also independent of z. It is obvious that the value of this integral is determined by that of $\sin\varphi'$,* so that

$$\int_{-R\sin\varphi'}^{+R\sin\varphi'} F\,\mathrm{d}\,x = f\sin\varphi'$$

which being substituted in (F'') we have

$$\int_{o}^{\pi} f\sin\varphi'\,\mathrm{d}\,\varphi$$

for the integral part whose variation consequent upon a change δz in the value of z must always be zero. Now we have, $\delta\varphi$ being $=0$, and $R\cos\varphi' = z\cos\varphi$,

$$\delta\int f\sin\varphi'\,\mathrm{d}\,\varphi = \int f'\sin\varphi'\ \delta\sin\varphi'\,\mathrm{d}\,\varphi$$

$$= -\frac{\delta z}{z}\int f'\sin\varphi'\,\frac{\cos^2\varphi'}{\sin\varphi'}\,\mathrm{d}\,\varphi,$$

where $f'\sin\varphi'$ is put for $\dfrac{\mathrm{d}\,f\sin\varphi'}{\mathrm{d}\sin\varphi'}$,

whence we must have

$$\int_{o}^{\pi} f'\sin\varphi'\,\frac{\cos^2\varphi'}{\sin\varphi'}\,\mathrm{d}\,\varphi = 0,$$

for all values of z from 0 to R. But it is obvious that $\dfrac{\cos^2\varphi'}{\sin\varphi'}$ is necessarily positive throughout the integration, and therefore in order that the complete integral may be zero, $f'\sin\varphi'$ must either be always zero or else must change its sign between the limits of integration, and that for all the values of z. Now this last is impossible, for whatever be the nature of the function, $f'\sin\varphi'$, its value and sign must be the same above the limit of $\varphi' = \frac{1}{2}\pi$ as below it,† and limits $\frac{1}{2}\pi - v$ and $\frac{1}{2}\pi + v$ can be assumed for the values of φ', within which the value of $f'\sin\varphi'$ being, if possible, greater than zero, does not change its sign. But the value of z can be taken so small as to bring the values of φ' within those limits throughout the whole integration. The

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* Not that this is necessarily true, but that it is so in the present case where the value of F is the same whether φ' be greater or less than $\frac{1}{2}\pi$.

† Not necessarily but because this is the case with the function $f'\sin\phi'$.

value of the integral therefore cannot be zero for all values of z unless

$$f' \sin \varphi' = 0$$

and consequently

$$f \sin \varphi' = \int_{-R \sin \varphi'}^{+R \sin \varphi'} F \, \mathrm{d}\, x = \text{constant.}$$

Let now the function F be expressed as a series of powers of its root $R^2 \sin^2 \varphi' - x^2$, so that

$$F = L \, (R^2 \sin^2 \varphi' - x^2)^n + L' \, (R^2 \sin^2 \varphi' - x^2)^{n'} + \text{ \&c.}$$
$$= \Sigma \left\{ L \, (R^2 \sin^2 \varphi' - x^2)^n \right\}$$

Then putting $x = u \, R \sin \varphi'$, we shall have

$$\int_{-R \sin \varphi'}^{+R \sin \varphi'} F \, \mathrm{d}\, x = \Sigma \left\{ L \, (R \sin \varphi')^{2n+1} \int_{-1}^{+1} (1 - u^2)^n \mathrm{d}u \right\}$$

The second member of this equation expresses a series of powers of $R \sin \varphi'$, and this series cannot be constant or independent of φ', except for the single term in which the exponent of the power is $= 0$ or $n = -\frac{1}{2}$. The coëfficients of all the other powers must $= 0$, and this requires that $L = 0$ in those terms since $\int_{-1}^{+1} (1 - u^2)^n \mathrm{d}\, u$ is necessarily greater than zero for all values of n. This reduces the above value of F to

(G) $$F = L \, (R^2 \sin^2 \varphi' - x^2)^{-\frac{1}{2}} \text{ and}$$

$$\int_{-R \sin \varphi'}^{+R \sin \varphi'} F \, \mathrm{d}x = L \int_{-1}^{+1} \frac{\mathrm{d}\, u}{(1 - u^2)^{\frac{1}{2}}} = 2L \sin^{-1} 1 = L \pi.$$

Substituting this value in (F″) and putting $L = KR$ we have

(F‴) $$\frac{\mathrm{d}P}{\mathrm{d}\, s} = \tfrac{1}{2} CKR \pi^3.$$

13. If we now draw the chord pho perpendicular to mn we have $(\mathrm{R}^2 \sin^2 \varphi' - x^2)^{\frac{1}{2}} = (kh \,.\, hl)^{\frac{1}{2}} = hp$ or ho, and consequently the value of $\frac{\mathrm{d}\, Q}{\mathrm{d}\, t}$ or F as given in G becomes

$$\frac{\mathrm{d}\, Q}{\mathrm{d}\, t} = K \frac{R}{ho}$$

where K is the value of $\frac{\mathrm{d}\, Q}{\mathrm{d}\, t}$ at the centre of the circle.

When, therefore, an electric current is generated in a long straight cylindrical wire, by an electro-motive force that acts uniformly throughout its mass, the rate of initial development of the

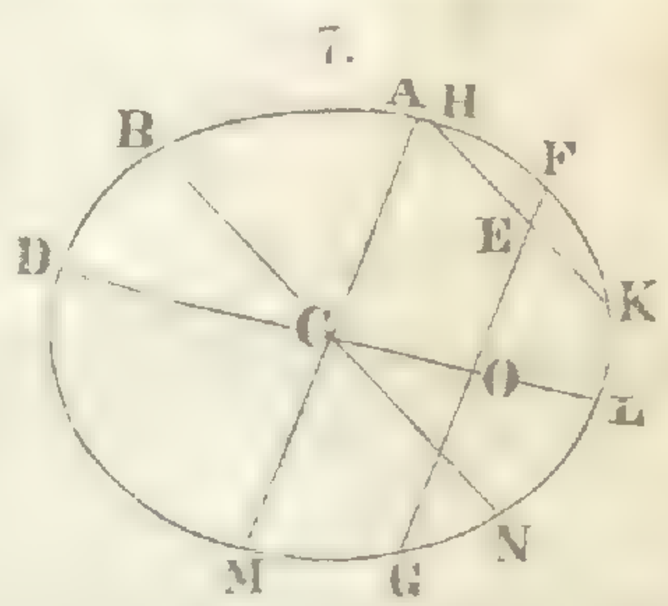
current through any fibre will be inversely as the length of the shortest chord that can be drawn in the cross section through that fibre.

14. The equation (F‴) gives us the inductive force for any point within the wire. For a point exterior to it, the quantity φ' or z does indeed, in the process of integration, eliminate itself from $\int_{-R\sin\varphi'}^{+R\sin\varphi'} F\,dx$ in the same manner as before, but z now becomes an element of the limits of the second integration with reference to φ, or in other words, the interval between the lower and upper limits of φ is confined to the angle subtended by the cross section of the wire, and if this angle be denoted by β, the integration gives us for an exterior point

$$(F'''') \qquad \frac{dP}{ds} = \tfrac{1}{2}CKR\pi^2\beta,$$

which shows that for a current following the law of development just deduced, the exterior inductive force at different distances is directly as the angle subtended by the cross section of the wire. The inverse ratio of the distance from the centre would require it to be as the sine of half the subtended angle, so that in the very near vicinity of the wire the induction could not be estimated as if the current were all generated through the axis of the wire.

15. In a conducting wire having its cross section an ellipse, a law of development would obtain perfectly analogous to that of the cylindrical wire. Let ADG, fig. 7, represent the cross section and E any point in it. Draw the chord GEF making any angle φ with a given line, and let HEK be the chord which is bisected in E, and parallel to GEF and HEK draw the diameters ACM and BCN, and draw DCL bisecting GEF in O. Let $CA=r$, $OF=cr$ and $OE=x$. The properties of the ellipse give us



$$\frac{HE^2}{BC^2} = \frac{GE.EF}{AC^2} = \frac{c^2r^2 - x^2}{r^2}$$

If then the rate of development through E be always equal to

$$L\frac{BC}{HE} = L\left(\frac{c^2r^2 - x^2}{r^2}\right)^{-\frac{1}{2}}$$

and this be substituted in (F′), we shall have for the inductive force at any point within the section

$$\frac{dP}{ds} = \tfrac{1}{2}CL\int_0^{\pi} r\left(\int_{-cr}^{+cr}(c^2r^2 - x^2)^{-\frac{1}{2}}dx\right)d\varphi = \tfrac{1}{2}CL\pi^2\int_0^{\pi} r\,d\varphi,$$

that is

If a current be generated in a conducting wire whose cross section is an ellipse, in such manner that the rate of development through any fibre, shall be in the inverse ratio of the chord bisected by that fibre, and in the direct ratio of the diameter to which that chord is parallel, the inductive force will be the same in all parts of the cross section.

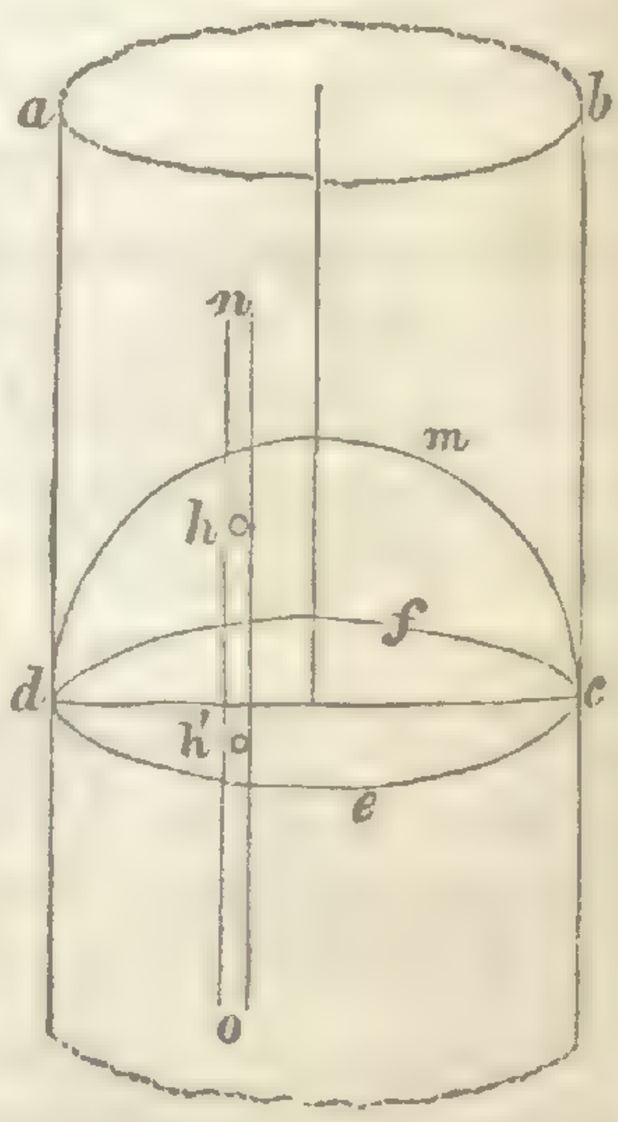
16. These results, if the fundamental law of induction as laid down be really true, leave no doubt that the initial development of a current in an extended wire, is more rapid at and near the surface of the wire than at the centre, and that in round wire it follows the law indicated in 13. In the case of a galvanic current, the resistance to conduction would come in as an element and interfere with this law as the quantity of current increases, until finally the electro-motive force comes into equilibrium with the resistance to conduction, when the current becomes uniform in quantity throughout the mass of the wire. But in discharges of common electricity, and in the slight currents that take place in electric waves of moderate length, there is strong reason to believe that the resistance to conduction is in most cases trifling compared with the inductive force, because the charge is exhausted before the current has had time to reach more than a very small fractional part of the quantity that would be maintained by the electro-motive force applied. In the discharge of a Leyden jar through a wire, the quantity of electric fluid passed is almost infinitesimal compared with that of a galvanic current excited even by a very small galvanic battery, in a moment of time, while the electro-motive force due to the intensity of the charge is beyond comparison, greater than that of our most powerful voltaic combinations, and could this immense force be continued till the resulting current had made any thing like an approach to its maximum quantity, the wire would be almost instantly dissipated, perhaps with explosions, unless that maximum were reached and passed in a space of time inconceivably minute. It is highly probable that future investigations will show that this latter alternative must in most cases be rejected. Some unpublished experiments of Prof. Page which I had the pleasure of witnessing, made with very heavy coils of wire, showed in that case a very sensible and even measurable space of time, to be necessary for the complete development of the current by the force of a galvanic battery, and this time should be the same in the same conductor for any other electro-motive force however great. The complete settlement of this question of the time required for the current to reach its maximum, or of the rate at which it will approach it in a given conductor, depends on the experimental determination of our constant C. On the strength of these considerations, I propose further on to develop the laws of electric discharges

through metallic wires, on the presumption that the resistance to conduction is slight compared with the electro-motive and inductive forces concerned, it being understood however, that they are offered only as conclusions to be hereafter submitted to the test of experiment.

17. In discharging a Leyden jar through a wire, the current once generated by which the discharge is effected, is not to be checked except by the exertion of a similar amount of electro-motive force in the contrary direction to counterbalance or neutralize the induction at the cessation or falling of the current. Hence the current rushes on as if it had momentum, until it charges the coatings of the jar oppositely to their original charge, when a second discharge in the opposite direction to the first commences, and thus a series of vibrations ensues, as first suggested by Prof. Henry, which ought to be perpetual if they were not gradually reduced by the resistance of the wire and of the space in which the spark occurs. The latter resistance is probably small after the air is once penetrated and so continues, we may reasonably believe, as long as the vibrations last. These conditions are absolutely essential to the existence of this succession of vibrations, and therefore receive strong support from numerous unpublished experiments of Prof. Henry, in which he informs us he has shown the existence of these vibrations in the discharge of a jar.

18. It may not be uninteresting to trace some geometrical relations. In fig. 8, let *a b c d* be a portion of a conducting wire, of which *def* is a cross section, and on *def* imagine a hemisphere *dmc* to be erected, and let any longitudinal prismatic element or fibre *no* of the wire be cut by the hemispherical surface and by the cross section so as to form the sections *h* and *h'*, *h'* being in fact the projection of the small spherical surface *h* upon the plane *def*. Now if *h'* be constant, the area of *h* it will readily be seen is inversely proportional to the shortest chord that can be drawn in the circle *def* through *h'*. Hence the rate of development of the current conducted by the elementary prism *no* is proportional to the area of the section of the latter by the spherical surface inscribed in the wire. And what is thus affirmed of an elementary prism may obviously, by adding together many elementary prisms, be extended to any finite prism. The development of current in it in an electric discharge is measured by the area of the section of it by the spherical surface.

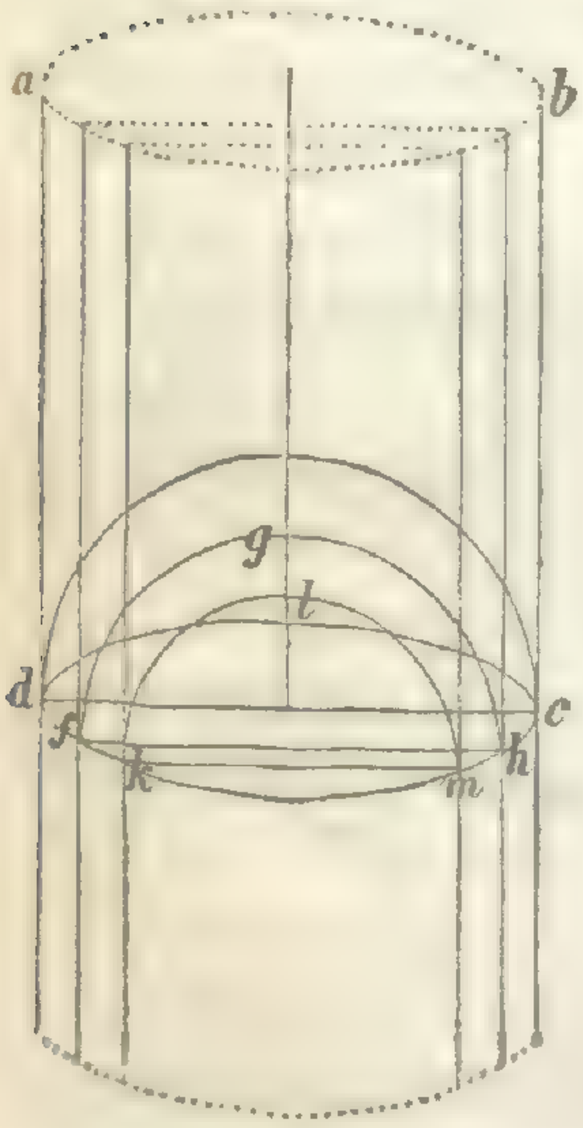
8.



19. In fig. 9, let the conductor *abcd* be cut longitudinally by two parallel planes whose intersections with the spherical surface form the zone *fghklm*. The area of this zone is simply proportional to the distance between the two planes, and therefore by what we have just seen, the same is true of the rate of development of current in the plate of metal included between the cutting planes, and the same relations will obviously exist with the quantity of current, at any given instant of time as with the rate of development.

20. From this it would appear that if an electric jar or battery were discharged through a cylindrical conductor composed of flat metallic plates of equal thickness, in the manner represented in fig. 10, each plate, whether the wide central ones or the narrower ones near the sides, would conduct the same part of the whole charge.

9.



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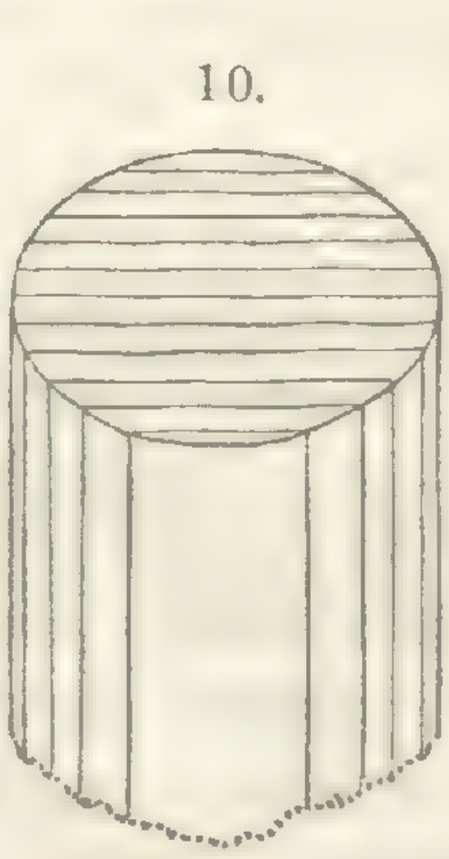

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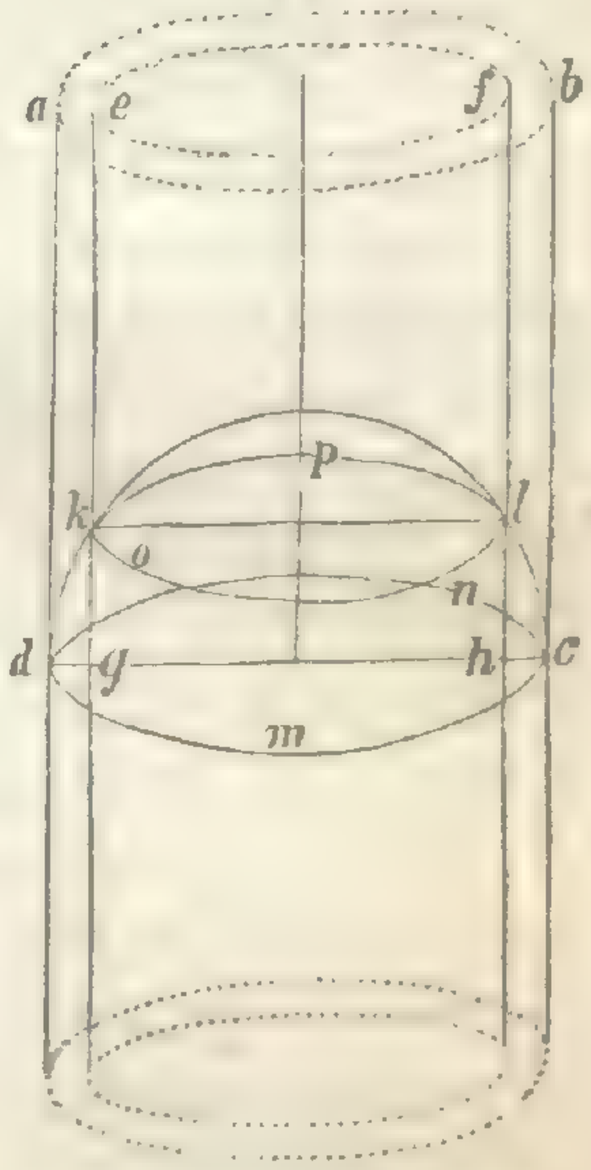

21. If we would estimate the comparative rate of initial development of a current in a thin shell *a b c d e g h f*, (fig. 11,) of a cylindrical conductor, we have only to consider the area of the spherical zone *d m n k o p* which it covers, and which area is proportional to the altitude *gk* of the zone. The thinner the shell the greater manifestly is the ratio of this altitude to the thickness of the shell, till at the extreme surface the ratio is infinite and the development instantaneous, so that the current would there begin from the first instant to feel the resistance to conduction. It is manifest however, from an inspection of the figure, that extreme rapidity of the initial development extends only to an extremely minute depth into the wire, and not far enough to make the effect of resistance there, affect sensibly the general character of the current in the case of those electric discharges which we are considering. Notwithstanding, then, the comparative quick-

ness with which resistance to conduction is felt at the surface, the quantity actually developed in proportion to the mass very near the surface, would be extremely great in comparison with the quantities developed at greater depths, and this tendency of the initial current to the surface does certainly offer some analogy to the accumulation of statical electricity at the surface, though with the difference that the great proportion of the current does, notwithstanding, take the interior of the conductor. One tenth only of the whole initial development belongs to the external shell equal in thickness to the two hundredth part of the radius, which would include a hundredth of the mass nearly.

22. But this thin shell would, nevertheless, conduct ten times its share of the current minus the allowance to be made for resistance to conduction, and we ought therefore, according to the foregoing conclusions and views of the character of the discharges of common electricity, to perceive the mechanical or heating effects of such discharges much sooner on the surface than in the interior of the wire. When, however, we consider the great thinness of the shell exposed to any great excess of current, and the readiness with which any heat generated would be conducted away by the metal within, it can hardly be considered a very serious objection to our conclusions if no instance has yet been adduced of a lightning rod or conducting wire, having its mere surface melted away, especially in the absence, so far as I am informed, of any experiments specially directed to that point.

23. As a test of the conclusions I have ventured to put forth, it might be proposed to coat a conducting wire with a thin sheet of the same, or a more refractory metal, separated from the main wire, except at the ends, by a bad conductor of heat, and to discharge through the whole a heavy electric battery. I have essayed such an experiment but find my small electrical machine and battery altogether insufficient to furnish the necessary quantity.

Law of conduction of a discharge of common electricity through a straight conducting wire.

24. If it be true, as we have supposed above, that the principal part of the resistance encountered by a discharge of common electricity through a wire, is due to the induction of the current upon itself, it is obvious that the law of conductibility of wires of different lengths for such discharges, is quite independent of their conductibilities for galvanic currents. In proceeding to deduce the law of conductibility or conducting power for electric discharges, so far as it has reference only to the induction of the current upon itself, it will be necessary to begin with a precise definition of conducting power. In galvanic electricity the conducting power of a wire may be said to be proportional to the quantity of statical electricity that can be propelled through it in a given time by a given electro-motive force after the cur-

rent has reached its maximum and become constant. This is the obvious definition, and we shall adopt a like one for the conducting power for a discharge of common electricity except that, in the time, we are confined to the minute space of time occupied by the discharge, and in which the current is supposed to make but a slight approach toward the maximum or constant state.

25. Let Q' represent the whole quantity of statical electricity, that passes through the wire during the time t elapsed after the instant when the electro-motive force begins to act. Then $\frac{\mathrm{d}Q'}{\mathrm{d}t}$ will represent the whole quantity of the *current* at the end of the time t, and $\frac{\mathrm{d}^2Q'}{\mathrm{d}t^2}$ will represent the rate of development of the current in the whole wire. Let K represent as before the value of $\frac{\mathrm{d}Q}{\mathrm{d}t}$ at the centre of the cross section *abd* fig. 6, of the wire.

Then by the law above laid down, the value of $\frac{\mathrm{d}Q}{\mathrm{d}t}$ at any point in the circumference of any circle concentric with *abd*, and whose radius is r, will be

$$\frac{KR}{\sqrt{R^2-r^2}}$$

and this multiplied into the area of the elementary ring included between the limits of r and $r+\mathrm{d}r$ will give

$$2\pi r\,\mathrm{d}r\,\frac{KR}{\sqrt{R^2-r^2}}$$

for the rate at which the current is developed through the elementary ring; and the integral of this taken between the limits of $r=0$ and $r=\mathrm{R}$ will give the rate of development of the whole current thus

$$\frac{\mathrm{d}^2Q'}{\mathrm{d}t^2}=2\pi KR\int_0^R\frac{r\,\mathrm{d}r}{\sqrt{R^2-r^2}}=\pi KR^2$$

whence we have

$$K=\frac{\mathrm{d}^2Q'}{\mathrm{d}t^2}\,\frac{1}{2\pi R^2}.$$

If we now substitute this value of K in equation (F'''), then, still supposing the length of the wire to be great in comparison with its diameter so that the short spaces at the extremities in which there is any sensible change in the relations of the development of the current to the section of the wire and to the induc-

tion force may be neglected, equation (F''') will obviously give us for the induction throughout the whole length S of the wire

$$P=\tfrac{1}{2}CKRS\pi^3=\tfrac{1}{4}C\pi^2\frac{\mathrm{d}^2Q'}{\mathrm{d}t^2}\frac{S}{R}$$

(*a*) whence $$\frac{\mathrm{d}^2Q'}{\mathrm{d}t}=\frac{4}{C\pi^2}\frac{R}{S}P.$$

Here the whole inductive force P is, agreeably to the hypothesis we are now considering, the only resistance encountered by the current. It must therefore be equal to the electro-motive force that generates the current and we shall now call P the electro-motive force. If this be supposed constant during the time t, equation (*a*) gives us

(*b*) $$\frac{\mathrm{d}Q'}{\mathrm{d}t}=\frac{4}{C\pi^2}\frac{R}{S}Pt$$

and this gives

(*c*) $$Q'=\frac{2}{C\pi^2}\frac{R}{S}Pt^2$$

from which it appears that the quantity of statical electricity passed through the wire by a given electro-motive force in a given time, or the conducting power of the wire for an electric discharge, is proportional to its *diameter*, and inversely proportional to its length.* This differs essentially from the law of conduction for galvanic currents in that the conducting power is directly as the diameter, while in constant galvanic currents it is as the cross section or square of the diameter.

Again, equation (*c*) shows that the conducting power (measured by Q') and the resistance to discharge, (measured by P), may be considered as the reciprocals of each other, since any change of R or S that will increase Q' while P is constant, will diminish P in the same ratio when Q' is constant.

I have here considered P as constant during the time t, but this is not true in practice in an electric discharge, since the electro-motive force due to the tension of the charge must diminish as the charge proceeds. Hence, although the above may be regarded as the expression of a law, still the only way in which we can practically bring the conductibility or resistance to discharge of two wires into strict comparison, is by passing a charge of machine electricity through the two simultaneously, either by dividing it between them, or joining them end to end and passing the whole charge through both.

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* It would be easy to show in a general way, that this law of electric discharge should apply to straight conductors having similar cross sections of any form, but I do not contemplate testing it with any other than round wire.

And first, if we divide the charge between the two wires, we must now integrate (a) considering P as a function of the time, and two successive integrations give us

$$\frac{\mathrm{d}Q'}{\mathrm{d}t} = \frac{4}{C\pi^2}\,\frac{R}{S}\int P\,\mathrm{d}t$$

and

$$Q' = \frac{4}{C\pi^2}\,\frac{R}{S}\iint P\,\mathrm{d}t^2.$$

Now as the discharge is divided between the wires, the electromotive force P at any given instant, is the same obviously in both wires and consequently $\iint P\,\mathrm{d}t^2$ is the same in both, and the quantity of statical electricity Q' discharged by each is consequently as its diameter and inversely as its length.

Secondly, if we pass the whole charge through both wires joined end to end, the quantity Q' that shall have passed at any given instant must be the same in both, and consequently also the value of $\frac{\mathrm{d}^2 Q'}{\mathrm{d}t^2}$. Hence equation (a) shows that

$$\frac{R}{S}P$$

must have the same value in both wires, so that P the resistance to discharge, is inversely as the diameter of the wire and directly as its length.

In all the foregoing investigations relating to the discharge of accumulated statical electricity, although the length of the wire has been supposed great, in comparison with its diameter, yet we have proceeded on the tacit supposition, that its surface is not sufficient to absorb any sensible part of the charge to be passed through it. But if the wire be of such length as to give it an extensive surface capable of itself receiving or absorbing the charge, the current of discharge will be no longer simultaneous through the whole length of the wire, and the phenomenon of electrical waves will come in, which is probably nothing more than the successive charging or discharging of the surface of the wire.

Washington, D. C., August, 1850.

Art. III.—*On Meteorites;* by Charles Upham Shepard.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

1. *Tuttehpore, Hindostan, Nov.* 30, 1822.

This stone, so far as I am informed, has not been described. It is barely mentioned by Prof. Partsch, in the appendix, p. 142, of his Catalogue of Meteorites in the Imperial collection at Vienna, (1843) as not yet brought into Europe. While in Edinburgh last year, I was informed by Alexander Rose, Esq., that a fine specimen of this locality existed in the cabinet of Thomas McPherson Grant, Esq., by whom I was very obligingly presented with a fragment, and the means of making the present communication.

The fall took place in the evening at Tuttehpore, which is situated seventy-two miles from Allahabad on the Cawnpore road, in lat. 25° 57′ N., and long. 80° 50′ E. The meteor from which the stone was ejected, was of large size, surpassing the full moon in apparent magnitude as well as splendor. It passed from southeast to northwest. A number of stones fell, the largest of which weighed 22 lbs., but that in the possession of Mr. Grant was the only one in an entire state, which was found. It was brought from India by Dr. Tytler, by whom it was presented to its present owner.

The stone is oval, slightly compressed, indented, and possesses a brownish black crust. Its weight is about two pounds. It is fine grained, trachytic and resembles most closely the stones of Poltawa (March 12, 1811), and of Castine (May 20, 1848.) Sp. gr. =3·352.

2. *Charwallas,* 30 *miles from Hissar, India, June* 12*th,* 1834.

This is another stone of which the only notice I have met with is found in the Appendix of the above mentioned work, (p. 143).—Prof. Partsch remarking that no portion of the mass had made its way into Europe. The entire stone is in the possession of Prof. Jameson, to whom it had been presented by a relative resident in India at the time of its fall. Its exact weight I am not able to give; but I have the impression that it cannot fall short of 7 or 8 lbs. I owe a fine slice of several ounces weight to the kindness of Prof. Jameson, from an examination of which, I am able to give the following description.

It is one of the toughest stones, if we except those of Chantonnay (Aug. 5, 1812) and Cabbarras Co., N. C., (Oct. 31, 1849), with which I am acquainted. It is filled with iron rust, like certain weathered, fine grained granites, in consequence of which, and the smallness of the particles of composition, it is impossible to recognize the mineral species, (with the exception of the nickeliferous iron) of which it is made up, although olivinoid, and one of the feldspar species, appear to be the leading ingredients.

On exposure to the air, it deliquesces, yielding chlorid of iron; but this does not prove chlorine to have been an original ingredient of the stone, since the mass, as in the case of one of the Iowa (Feb. 25, 1847) stones, may have been since its fall in some situation where chlorine has been imparted to it.

Its specific gravity is 3·38. It contains 15·07 per cent. of nickeliferous iron, with traces of sulphur. The stoney part consists of silica, magnesia, protoxyd of iron, alumina and lime.

3. *Meteoric Iron, County Down, Ireland. Fell August* 10, 5 P. M., 1846.

For a knowledge of this meteorite I am indebted to my friend Dr. John Scouler, Prof. of the Royal Dublin Institution, who wrote me as follows respecting its fall, in February, 1848. "I believe I must give you the credit of having discovered another meteorite in Ireland, or in other words, but for you I would not have been at the pains of finding it out. The stone or stones fell in 1844, in the north of the county of Down, and were seen to fall by some of the coast guard. You will find two small specimens of this stone along with the other specimens in the box." Owing to an accident in the transmission of the box, the specimens were not received until within a few months, and hence the delay in making known this interesting fall of meteoric iron. The only additional information concerning the event, which I am at present able to communicate, is the circumstance mentioned in the label accompanying the specimens, "that the name of the man who saw the mass fall and who picked it up, was Gibbon."

The following is all that I am able at present to make known concerning the mass. It is malleable, homogeneous, and amygdaloidal. Specific gravity variable: vesicular portions = 5·9. Crust thick, sometimes one-third of an inch and consists of mixed oxyds of iron, somewhat coated by blue phosphate of iron, (vivianite.) In moist air, the chlorid of iron deliquesces in little drops. It does not afford the Widmanstättian figures. It does not contain nickel, cobalt, or sulphur.

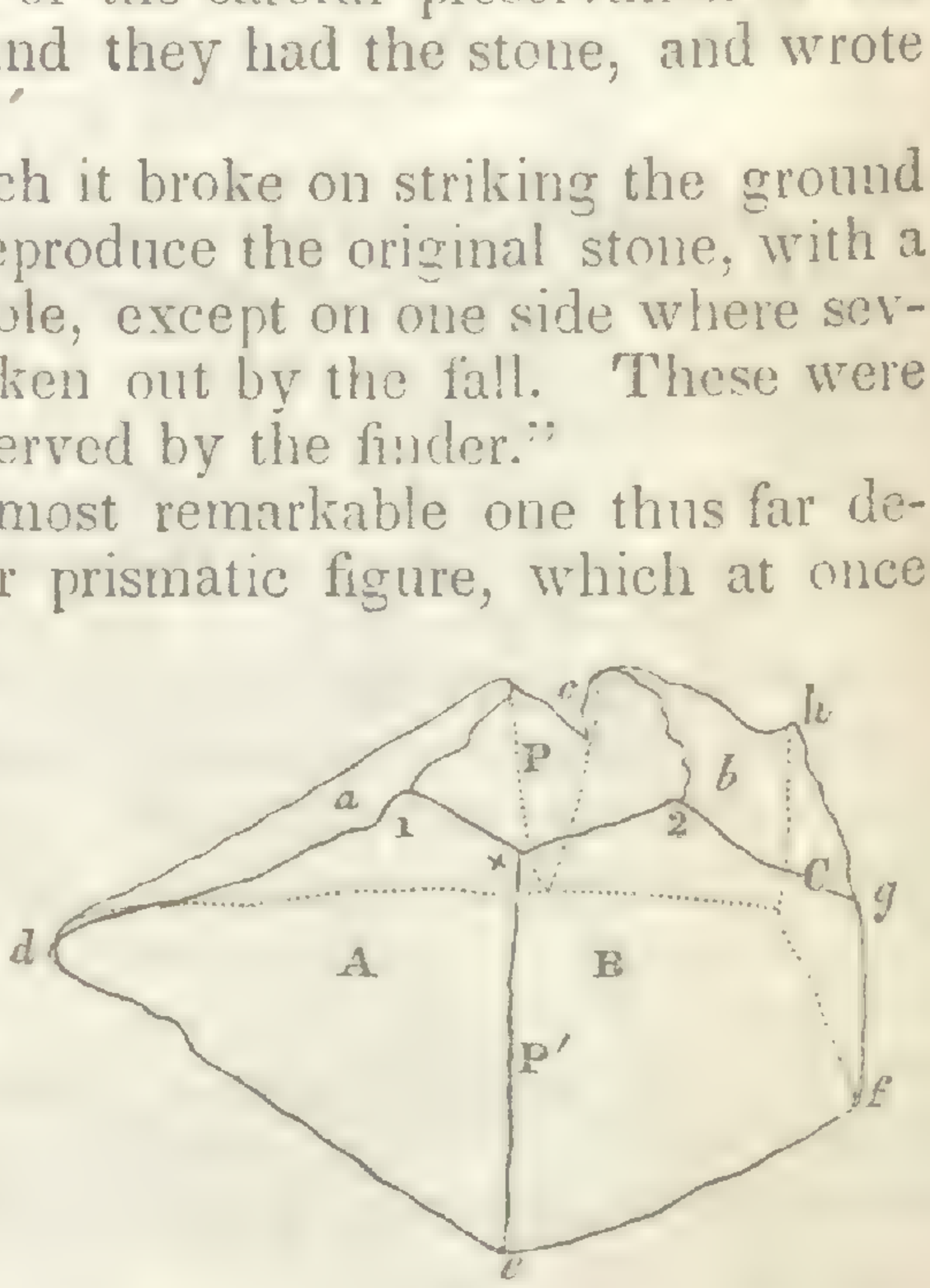
4. *Description of a large stone of the Linn Co., Iowa, fall of Feb.* 25, 1847.

This stone, weighing twenty pounds, has lately come into my hands through the agency of Rev. R. Gaylord, of Hartford, Iowa, the same gentleman who procured for me the specimens which were picked up at the time of the explosion of the meteor, and of which an account was given at a former meeting of the Association, (see vol. iv, 288, 289, of this Journal.)

The following statement respecting it is from the Rev. Mr. Gaylord's letter of July 3d, 1850. "It was found (in the summer of 1847) in Hooshier grove by Abner Cox. He was in company with John Hollis, of whom I obtained two fragments three years ago. They have had the stone two years or more, and by lying in the loft of a smoky cabin, it is somewhat dingy in appearance. This John Hollis is the man who ground up so much of the stones that were seen to fall, in order to get silver. He was the means, however, of the careful preservation of the present mass. Dr. Knight found they had the stone, and wrote me respecting it.

"The three pieces into which it broke on striking the ground fit together exactly, so as to reproduce the original stone, with a complete coating over the whole, except on one side where several small fragments were broken out by the fall. These were gathered up carefully and preserved by the finder."

This stone is perhaps the most remarkable one thus far described, for its highly regular prismatic figure, which at once suggests the idea of a portion of a basaltic column. Nor can the geologist look upon it without feeling almost certain, that it once formed part of some extensive formation in the world from whence it came.



Its dimensions will be best understood from an examination of the annexed figure. P and P′ are the bases. A B and C the vertical sides of the prism: 1 and 2 constitute the less regular 4th and 5th faces of the figure. *c* denotes a portion of the stone which is wanting. *a* and *b* are sloping sides, *a* inclining to P under an angle of about 130°, and the diagonal of *b* to the line *g f*, under 100°. The surfaces P and P′ are nearly flat, and agree in presenting a peculiar wavy undulating surface and a deeper black color than belong to the other faces of the stone, a difference which appears to originate

in the nature of the horizontal cleavage of the mass as contrasted with that which is vertical or oblique.

The greatest diameter of the base P′ is $10\frac{1}{4}$ inches.

From	*e* to *f*	measures	$6\frac{1}{2}$	inches.
"	*e* to *d*	"	7	"
"	*e* to *x*	"	$5\frac{3}{4}$	"
"	*g* to *f*	"	$3\frac{3}{4}$	"
"	*g* to *h*	"	$3\frac{3}{4}$	"
"	*x* to 2	"	$2\frac{1}{4}$	"
"	*b* to *g*	"	$4\frac{1}{2}$	"

The fragments which came from the chink *c* are rich in chlorine, deliquescing freely with chlorid of iron when exposed to a moist state of the air; while the rest of the stone is quite free from this constituent, and precisely resembles the other stones of the locality already described. This difference of composition in one and the same stone is probably owing to the fact, that the fragments in question must have remained for a considerable time partially buried in the soil and have imbibed the chlorine from thence; while the main mass being above ground and more protected by its coating was preserved from such an impregnation.

5. *Meteoric Stone of Waterloo, Seneca Co., N. Y.; fell in the summer of* 1826 *or* 1827.

For my first knowledge of this remarkable stone, I am indebted to Prof. O. Root, of Hamilton College, from whose letter dated Clinton, N. Y., Jan. 26, 1850, the following abstracts are made. "On receiving your note, I wrote to my friends in Geneva, for the meteorite mentioned in my letter to President Hitchcock. Judge Watkins very willingly gave the specimen, and it is now in my possession, subject to your order. The piece is not large (it weighs about 1000 grs.,) as the original mass had been divided two or three times. Not being familiar with such productions my opinion concerning its genuineness is of no value. Judge Watkins, however, is a gentleman of high respectability, and I have confidence in what he relates of the history of this stone. My attention was directed to the subject in the following manner. A year or two ago, while showing some gentlemen a fragment of the Otsego meteoric iron, one of them observed that he remembered a report many years back of a stone falling through a roof in Waterloo, or in that vicinity. After many inquiries, I at last found the stone or a fragment of it, with Judge Watkins. He relates that a hole was discovered in the roof of his mill directly over a bin of wheat,—that the opening was made through the shingles where the roof-boards were about five inches apart (although a piece was split from the roof-board on one side),

and that under the hole there appeared a depression in the grain, which led to an examination that resulted in the discovery of the stones. The Judge inferred that the stone had fallen through the roof, as its size was too great to have allowed its admission into the bin along with the grain, which was raised by means of elevators. He also supposed it to have been of atmospheric origin, as the mill was four stories high, and as the nature of the stone was unlike any of the mineral productions of the region, the rock in place at Waterloo, being the Seneca limestone. He was not positive whether it was found in 1826 or 1827. The stone was divided for Dr. Hale, President of Geneva College."*

The specimen presented me by Prof. Root, had been left for upwards of twenty years in the garret of Judge Watkins, where it appears to have been mistaken for something edible by the rats, who have left numerous markings of their incisor teeth upon its surface. Indeed, in color and texture, it nearly resembles common rhubarb. Its color is light buff or yellow. It is slightly coherent, and may easily be crushed between the fingers. Its sp. gr. =2·30. But a small portion of the original crust remains, which is reddish brown. The stone contains in small quantity, blackish particles attracted by the magnet. A surface produced by being cut with a saw, shows waved parallel lines of greater hardness than the rest of the stone. It consists of

Silica, ...	78·80
Peroxyd of iron, ...	8·72
Alumina, ...	6·28
Moisture, ...	4·75
	98·55
Lime and magnesia (in equal quantities) and loss,	1·45
	100·00

6. *Specific gravities of two meteoric irons.*

Meteoric iron of Pittsburg, Pa., . .	7·380
Meteoric iron of Salt River, Ky., . .	6·835

* I addressed a letter of inquiry to Dr. H., who informs me that the specimen has for some time been lost sight of in the college collection.

Art. IV.—*An Essay on the Classification of Nemertes and Planariæ: Preceded by some general considerations on the primary Divisions of the Animal Kingdom;* by Charles Girard.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

I.

I am gathering materials for a monograph of the Nemertes of this side of the Atlantic. I have already said on another occasion that I was doing the same with regard to the Planariæ. It will not be anticipating the final results of these investigations to present here some general considerations respecting the place that may conveniently be assigned to these animals in our zoological system.

The chronological history and the position that the various authors have assigned to the Nemertes and Planariæ having been fully brought out by Mr. de Quatrefages,* I shall not dwell upon that part of the subject.

The question now under consideration bearing merely upon the fundamental groups of the animal kingdom, I need only go back to Cuvier, since he established these groups and since the foundations of our classification are the results of his labors.

Nor shall I at present enter upon the secondary divisions to be established among the Nemertes and Planariæ; this aspect of the question cannot be settled until we are better acquainted with the organization of the group of Rhabdocœla or freshwater Planariæ.

II.

Before however I treat of the Nemertes and of the Planariæ in a more particular manner, I have a few words to say on the subordination of characters in the primary groups of the animal kingdom.

There are in the animal kingdom but two main systems of organs to which all the others are related, being in a word, mere dependences or branches of them. These two systems of organs are: 1. the *nutritive system* or *system of vegetative life*, and 2. the *sensitive system* or *system of animal life*.

Now which of these two systems of organs is the most important; in other words, which ranks highest as a zoological character. The nervous system, some physiologists will answer. But let us examine this point. What is the distinguishing character of the animal kingdom as a kingdom? A digestive cavity of some kind, into which are introduced nutrient substances neces-

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* Ann. Sc. Nat., 3d Série, iv, 1845, p. 129.

sary for the maintenance of living bodies; necessary to their growth anterior to the period of full development and to their equilibrium after having reached their complete size. The digestive system then is the universal character, common to all animals, and this character gives us the animal kingdom: it ranks then highest.

Next to the entire animal kingdom we have the four great primary divisions, the division of Vertebrata, the division of Articulata, the division of Mollusca and the division of Radiata, and these four divisions are characterized by the nervous system chiefly. The plan of structure of the nervous or sensitive system giving these divisions and these divisions exclusively, its importance is of a secondary degree. For the nervous system has not yet been materially demonstrated in all the Radiata, whilst the nutritive system is to be seen everywhere. Not that I deny the sensitive system to any animal even where it has not been shown. There exists among the lower Radiata a homogeneity of substance which is perhaps the only obstacle to its discernment; nevertheless the digestive system being everywhere distinct, this latter must have the preëminence.

It has the preëminence because it gives us the unity of the kingdom as we have also this unity in the perfect resemblance of all eggs at an early period of their history. In the animal the first substance which is formed is the vitellus or yolk; it is the foundation of the future being, it is, as Prof. Agassiz has observed, the being itself. Out of the yolk the nervous system originates as well as all other parts of the organism, so that in an embryological point of view the nervous system holds a second rank.

It is of secondary rank as a material organ and character of classification of animals. It plays the highest part by its immaterial essence in the human species. But here we leave the boundary of the animal kingdom and therefore the classification, which is our object, to enter another kingdom, the kingdom of Thought.

The nutritive system being the index of animality we see all animals equally compelled to take food; this is the essential condition of their existence.

The nervous system being the fundamental basis of the primary divisions, it gives to each division a special immaterial tendency so long taught by Prof. Agassiz. Now as there are four divisions there are also four of these tendencies. And as soon as there are four immaterial tendencies, there is an antagonism amongst them. This is a natural consequence since the nervous system overrules the division and its dominion is of a spiritual character.

The nervous system stamps upon the divisions their zoological form as the symbol of their diverse tendency. We shall see

further an *apparent* anomaly of this kind in the beings placed at the boundaries of two divisions where the material form, to use the words of Milne Edwards, escapes the supremacy of the nervous system. The principle however remains always the remote cause.

Besides the antagonism of the divisions between themselves, there is an antagonism between the instinct and the intellect, that is to say, three of the divisions against the fourth: the Articulata, the Mollusca and the Radiata, collectively known under the appellation of invertebrate animals, all of which have only instincts, against the Vertebrata which possess, beside instincts, intelligence to a certain degree.

Now between the invertebrate animals and the vertebrata the struggle is latent, passive, because the two principles, the instinct and the intellect, do not coexist. But among Vertebrata where we find both the instincts and the intellect in the same individual, the struggle is active and direct, and we are indebted to the observations of Fred. Cuvier, for the revelation of this astonishing law, that wherever the instincts command, the intellect is actionless, and wherever the intellect governs, the instincts are silenced or nearly so. There is a struggle and an open struggle; the victory of one of the principles involves the subjection of the other.

Morally speaking, we might thus establish two series in the animal kingdom; an instinctive series, stationary and sightless, and an intellectual series, progressive and seeing; the first including three divisions, (Radiata, Mollusca, Articulata,) and the second only one (Vertebrata).

And now, if we go back to the origin of the animal kingdom, and trace its history in the past, we see the two series appearing simultaneously from the first manifestation of life upon the surface of the earth: the instinctive series with its three divisions and all the classes; while the intellectual series is represented by one class only, that of fishes.

Their forms are renewed during a succession of periods and each great revolution of the globe adds one class to the division of Vertebrata or the intellectual series, in the order of their zoological gradation: Reptiles, Birds and Mammals:—then Man crowning the whole work. Thus a real progress is manifested in the division of Vertebrata while the Invertebrate animals remain what they were, although undergoing a renewal of forms. The reason of this is, as Fred. Cuvier states, that the instinct is innate, always sightless, necessary and unchangeable, whilst the intellect is progressive, conditional and susceptible of modifications.*

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* Flourens. Resumé des travaux de F. Cuvier, sur l'instinct et l'intelligence des animaux. Paris, 1844.

In the intellectual series there was an aim, a design, and this was, to arrive at man, the true domain of intelligence. This aim realized, the creation would stop and it did stop. Zoological forms had acquired all that diversity with which the sphere of activity of each division was endowed. To the immaterial principles nothing was left except a limited play, a contest for supremacy. To intelligence alone was given the power to arrive at the knowledge of the actual world, to look back in time, to contemplate itself in the past in view of the future, finally to study itself,—in a word, to *reflect*.*

The power of reflection belongs exclusively to man, the last being created. Man being the converging point of the material creation, in him were also to be concentrated in our time the struggles of the two spiritual principles of all past time.

One word more on the intellectual series. The fishes, reptiles, birds and mammals belong to this series, but the fishes, the reptiles, the birds and most of the mammals in their natural condition of life have no intelligence,—have no intellect.

The intellect resides within the brain, and the vertebrata alone have a true brain. The brain is composed of several parts. There is the base of the brain which sends nerves to the organs of sense, and the hemispheres, the special seat of the intellect. Now of the hemispheres the fishes have only a rudiment, and this is the reason why they have no intellect. There exists a well defined progression from the fishes to the mammals with respect to the development of the hemispheres; placed anteriorly in the fishes, they rise degree by degree in the other classes over the base which is gradually covered and concealed under them. Here we see the organ reflected upon itself, reminding us of its function in its full activity, reflection. To this gradual development corresponds a position of the head more and more raised which becomes vertical in man,—where it forms a right angle with that of fishes. One step more would have been retrograde: the development there stopped.

Thus by a gradation almost imperceptible we have beings belonging to the intellectual series which have the intellect only in a virtual state. They have the organ without having the principle, or at least admitting the principle virtually present, the organ is not sufficiently developed to allow its manifestation.

These general considerations, although a brief résumé, will perhaps appear out of place in this paper; but my object is the discussion of the value of the nervous system as a zoological character, and to show that while this system of organs gives only the divisions, these latter are governed by it in an absolute manner.

I now come to the special topic of my communication.

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* Flourens. Resumé des travaux de F. Cuvier, sur l'instinct et l'intelligence des animaux. Paris, 1844.

III.

The place assigned by Cuvier to the Nemertes and to the Planariæ in his "Animal Kingdom," is entirely provisional as acknowledged by the illustrious naturalist himself.

The Nemertes are placed in the division of Radiata immediately after the *Intestina cavitaria*.

Between Nemertes and the intestinal worms of this order there are only analogies. The extraordinary length of the body of some of them, for instance *N. Borlasii* (Borlasia angliæ), a length reminding us of the class of worms, and above all of some of the intestinals, such as the tape worm, had prevailed over all other considerations. Their affinities were not acknowledged because their organization was unknown.

At that time the intestinal worms were regarded as Radiata, for the reason that their nervous system had not been found, and the Nemertes, as well as Planariæ, were regarded as intestinal worms because all of them reminded us by their forms, of the forms of these last.

When the more recent labors of some zoologists had established beyond any doubt that the intestinal worms belonged to the division of Articulata, on account, first, of their having a nervous system, and a nervous system constructed on the plan of that group, secondly, by the structure of their body, which is composed of a series of articulations or rings movable upon each other, then the Nemertes were carried with the *Intestina cavitaria* into the division of Articulata where they remained as little known as before. It is but of late that they have been made the subject of a special study by a skillful zoologist, Mr. de Quatrefages, and I am surprised that this author has not pointed out the close affinities which they bear to Mollusca.

Cuvier was well aware of the space which separated Nemertes from intestinal worms, inasmuch as he foretold that they would one day constitute a new order. In spite of these external resemblances, their structure which as he says "*is of an extreme softness*," caused him to doubt. Nevertheless it did not, on this account, enter into his mind to compare them with Molluscs.

At that time, as indeed now, the idea of a mollusc corresponded with the idea of a shell-bearing animal, with the form of a body more or less drawn together into itself, while the lengthening of the body involved by analogy the idea of a worm.

Now if abstracting the form, which is not the characteristic of the divisions, we look at the intimate structure, if we give up also the shell as circumscribing the division of Mollusca, we shall find in the Nemertes all the principal characters of Molluscs: a soft body, entirely smooth, covered with a glutinous mucosity; a very simple nervous system reduced to a small number of cephalic

ganglia, whence nervous threads depart to distribute themselves in the body. If we further state that, as in the greater number of Molluscs, the surface of the body is covered with vibratory ciliæ which help their movements, movements generally slow, deprived of energy, then we directly arrive at the idea that Nemertes are really Molluscs,—Molluscs of a low rank, being parallel with the worms of the division of Articulata by the analogy of their forms.

Having discussed above the value of the nervous system as the predominant character of the *division*, exclusively of any other character, it remains only for me to state that the nervous system of Nemertes is constructed upon the plan of the nervous system of Molluscs: there exists a cephalic mass more or less lobed, representing either the superior æsophageal ganglion of other Molluscs, or that same ganglion to which, on account of the peculiar form of the body, are added the two or three abdominal ganglia. Nervous threads are distributed in all directions; two of them more voluminous than the rest, but uniform in structure, run along the sides of the animal, and sending off thinner threads without showing in their course those ganglia or swellings which distinguish the nervous system of Articulata, such as it is in Malacobdella, Peripates, &c.

The disposition of the nervous system of Nemertes, then, is merely *analogous* to that of Annelids; its structure is that of the nervous system of Molluscs.

IV.

The position of Planariæ in the division of Radiata is not less curious than that of Nemertes. Included in the second order of intestinal worms, the *Parenchymata*, they are brought near the Trematodes, to which they have only analogies, in the same sense as those that Nemertes have to the *Intestina cavitaria*.

The *Intestina parenchymata* have been withdrawn from the division of Radiata and brought into that of Articulata, and for the same reasons as that of the *cavitaria*. The Planariæ, of course, have thus been compelled to follow them in the same manner as Nemertes have followed the latter. But also little investigated at that time, their affinities with Molluscs have escaped the eyes of zoologists.

The Planariæ are not parasitical as Trematodes are, and it is important that this fact should be noted. parasitism existing most extensively among Articulata. The investigations of Mr. de Quatrefages and others have moreover made us acquainted with their structure which, although not yet entirely understood, as I believe, is however of the highest interest. Indeed in Distoma the digestive system is constructed upon an analogous plan with that of Planaria; but the digestive system, as we have said, can-

not characterize the primary *division*. It gives but the subordinate groupings.

As soon as it is acknowledged that the *division* rests upon the structure of the nervous system, the fact that the nervous system of Distoma is that of Articulata, and the nervous system of Planariæ is that of Mollusca, there is no ground for further hesitation.

In Distoma there are two cephalic ganglia, whence nervous threads part for the anterior region of the body. From each one of these ganglia arises a nervous thread which takes its course backwards: this thread presents on its length a series of small ganglia, scarcely distinguishable upon the middle region, it is true: but very apparent towards the posterior region, where they are seen sending off smaller threads distributing them to the body. This arrangement of the nervous system of Distoma becomes especially distinct in Malacobdella where the same arrangement is found, with the ganglia of the lateral threads more developed. Thus, taking the nervous system into consideration, Malacobdella is one degree higher than Distoma, then Clepsine would follow in which the two threads are brought so close together that they combine into one single thread. Above Clepsine would rank the other Hirudines.

In Planariæ we have a cephalic ganglion more or less lobed on its circumference which sends nervous threads to all the regions. There are two more voluminous lateral ones (one on each side of the body) as in Distoma, but uniform as in Nemertes, still recalling here by analogy the nervous system of Articulata. The fundamental difference, although lest apparent at first sight, consists in the absence of ganglia upon their lengths, and this fact decides all.

The body of Distoma, indeed, is not articulated and this may perhaps lead to a belief of a closer affinity between Planariæ and worms. Their broad and flattened form would be better adapted to their mode of life without that structure. Moreover the articulation of the body, although a character of the division, is subordinate to the nervous system. Consequently there is no ground for surprise at seeing it vanish or even entirely disappear in those groups placed at the boundaries of two divisions as a material property in litigation, disputed by antipathic vital tendencies, each endeavoring to appropriate it to itself.

Considering now the softness of Planariæ, that glutinous mucosity which surrounds them, that body of a uniform shape without articulations and deprived of articulated limbs, that general apathy, all these are so many characters which they partake with Molluscs and do not partake with Articulata.

However, I do not know that any one has proposed to consider these animals Molluses, although Baer and Dugès had already compared the inferior disk of Planariæ to the foot of Gas-

teropoda without thinking of bringing them together in the same natural group. Mr. de Quatrefages refutes this comparison. We shall come to it again presently.

For, if the shell does not characterize Mollusca, inasmuch as all living Cephalopoda are naked, and among Gasteropoda we have the whole group of Nudibranchiata deprived of a shell, that of Pteropoda, and among Acephala that of Tunicata, it requires no effort of imagination to admit in that division, animals such as Planariæ. They are flattened Molluscs in the same manner as Nemertes, are elongated or stretched Molluscs, as are also Dentalium, which nobody would place elsewhere than among Molluscs.

Many authors have spoken of the organization of Planariæ, from Dugès to MM. de Quatrefages and Blanchard. All have viewed them as worms, doubtless prepossessed by the idea that Cuvier who had established the divisions could not have been mistaken so far as to place side by side in the same order animals belonging to two different divisions.

But this error of the author of the "Animal Kingdom" is easily accounted for. At that time he was in want of the essential datum to settle such a question in its details, the knowledge of the nervous system.

The plan of structure of the nervous system, we have already said, and we cannot repeat it too often, gives only the division and nothing but the division. Now Cuvier did not know it when he laid the foundation of his classification; although he foresaw the four plans of organization of the whole kingdom; and as he said there are but four of these plans.

He who has done most after Cuvier to establish the doctrine of these four plans of organization, is Prof. Agassiz. He has the unquestionable merit of having followed out the traces of these plans beyond the existing creation, and in ascending through past ages of the world's history he has been enabled to reconstruct the biological phases to which I have alluded above. In reading the history of the earth on the strata which compose its crust as so many pages of a book written by the hand of the Creator, we then find again the thought of these four plans of organization preconceived by Cuvier, demonstrated as a doctrine by Prof. Agassiz.

These four plans of organization would acquire a far greater importance if embryology should ratify them. Now embryology does so. All embryological investigations past and contemporaneous lead towards four plans of structure. I shall not treat of this question more in detail here; it is sufficient merely to mention the fact.

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Now the question respecting the class among Molluscs to which Planariæ belong is easily settled. They crawl on the inferior

surface of their body; that they are Gasteropods. there can be no doubt. Do we not see them, as well as Pulmonata, Nudibranchiata and others, creeping along the walls of a basin and when near the surface of the water, reversing their position and walking in that manner with the same facility? Do we not witness the same undulatory contractions in that foot? Therefore were not Baer and Dugès guided aright when they compared the inferior surface of the body of Planariæ to the foot of Gasteropods?

I am not aware that any of the Planariæ I have studied moves with the same facility on the back as on the belly as Mr. de Quatrefages states. Whenever I placed them in that position I always saw them changing it as quickly as possible. Besides in most cases I have seen the upper surface differing widely from the inferior one.

In Planocera we have on the dorsal surface two cylindric tentacles, analogous to the cephalic tentacles of Doridians. In Thyzanozoon or Eolidicera, the cephalic tentacles are flattened and are brought entirely forwards while other tentacles appear on the back, reminding us of the dorsal appendages of Eolidians proper. Then come Proceros and Procerodes with but the flattened anterior tentacles of Eolidicera and in the same place as in these last.

There exist then in the marine Planariæ one group which reminds us of Doris, another of Eolis, and still another group intermediate between Eolis and Planaria proper which lead to the freshwater species.

This shows that it is near Nudibranchiata that Planariæ will find a natural place, and on several accounts we should be tempted to consider them as a degradation of that type.

But for us who do not admit the so-called degradations, inasmuch as each being appears to us as to Cuvier, *a perfect whole by itself*, we consider Planariæ as a family nearly allied to that of Nudibranchiata, bearing in itself the reason of its existence as strongly defined as this latter, and representing merely a variation in the thought of the Creator.

For, in Nudibranchiata we find a number of types all as much diversified. These are: *Doridians*, *Eolidians*, then *Cauthopsis* analogous to *Procerodes* which leads to the *Acteonians*, then finally the genera *Pelta* and *Chalidis* which constitute another group almost Planarian, deprived of external appendages of any kind.

There exists a striking parallelism between the zoological forms of these two families.

Viewed in the light of their organization nothing is more alike. The nervous and digestive systems scarcely differ. I have already spoken of the first. With regard to the second I shall recall the fact that it is ramified in Nudibranchiata as in Planariæ; the ramifications being diversified according to the groups.

The organs of generation do not differ much more. Nudibranchiata are androgynous like Planariæ. The fecundation takes place by mutual fecundation as is the case in Pulmonata. But in Planariæ we have cases where an individual fecundates itself, the hermaphroditism being here complete.

V.

It still remains for me to make some general remarks upon Nemertes and Planariæ.

Mr. de Quatrefages tells us himself, "neither Nemertes nor Planariæ have externally a resistant and tough layer, similar to that which is found with Annelids, for example, or even with Rotatoria."*

We have then two groups of Gasteropodous molluscs parallel with two groups of annulated Articulata: the group of Planariæ reminding us of Helminthes, and the group of Nemertes reminding us of the Hirudines.

At the extremes of these two groups, at the bottom of the two classes, we witness in some sort a strange and opposed struggle of the two immaterial principles of the divisions which exert themselves to take from each other some portion of their material property. As examples we have:

In Molluscs,—the Nemertes which elongate and become worm-like; the Planariæ which remain shorter but pressed down, spread out, flattened in thin leaves.

In Articulata,—the softness of Helminthes in general, the flattening of their body in Trematodes in which the articulation of the body vanishes, analogous to Planariæ;—the softness still of the Leeches with a distinct articulated structure, being parallel with Nemertes.

These groups do not oppose each other in an exact parallelism, for Nemertes which form a low type of Gasteropods are opposed to the Leeches of a higher grade of worms, and Planariæ a higher grade among Gasteropods are opposed to Trematodes a lower type among worms. In this manner:

In the elongation of the body of Nemertes there is nothing to surprise us. Placed at the bottom of the class to which they belong, they assume a form analogous to a group of the division of Articulata which attract them but to which they do not belong. Now when a Mollusc, whose body is elongated beyond all pro-

* Ann. Sc. Nat., 3d series, vol. iv, 1845.

portion, and obliged sometimes to move by the contraction of transverse muscular fibres, accelerates its progress, then we see that Mollusc assuming certain transverse, irregular and unequal folds,—shadows of articulations which in reality do not exist.

At the bottom of the division of Articulata we observe similar facts. The Trematodes lose insensibly that elongated form of the body which constitutes the prominent character of the worms; they are flattened, spread out, meanwhile the articulation of the body, the characteristic of their type, vanishes completely,—thus foreshadowing the type of Planariæ.

The position and number of eye-specks in Nemertes and Planariæ indicate also a greater resemblance to the same organs in Molluscs than to those of Annelids. When eyes exist in Annelids, they are arranged in pairs on both sides of each articulation or else form a crown on one of the anterior rings. In Planariæ we find the eye-specks irregularly grouped on the upper surface near the anterior region of the body. The same arrangement is observed in Nemertes. This arrangement forcibly reminds us of what we see in Gasteropods. In Planariæ alone they are more numerous and distributed with less constancy, a fact which is accounted for by the lower position of that family in the class.

The habits of Nemertes and Planariæ speak rather in favor of Molluscs than worms. Most of them live concealed under stones which is the case with many Molluscs, while I do not know any which lives within a tube constructed like those of worms.

The embryonic development of both Nemertes and Planariæ takes place according to the laws we witness among Gasteropods. The larval condition of both Gasteropods and Planariæ is very similar.

It is plain enough, Nemertes and Planariæ are only *analogous* to Articulata; by their *affinities* they are Molluscs. The division of Articulata hence appears to us as a type more natural and rational, as well as that of Mollusca: this latter including all animals which are soft, slimy and flabby, whatever may be their form.

* * * * * * *

The Rhabdocœlæ or freshwater Planariæ will be the connecting link by which the Nemertes approach Planariæ proper, as members of the same group. We may say of them that they are the freshwater representatives of both Nemertes and Planariæ. And now observe the transition: the group, Rhabdocœlæ, which is distinguished at once from Planariæ and Nemertes, this group, I repeat, lives in fresh waters, while the other two groups which they connect together are scarcely found beyond the boundaries of the seas. If some of them ascend the rivers it is within the limits where the water still retains a part of its marine character.

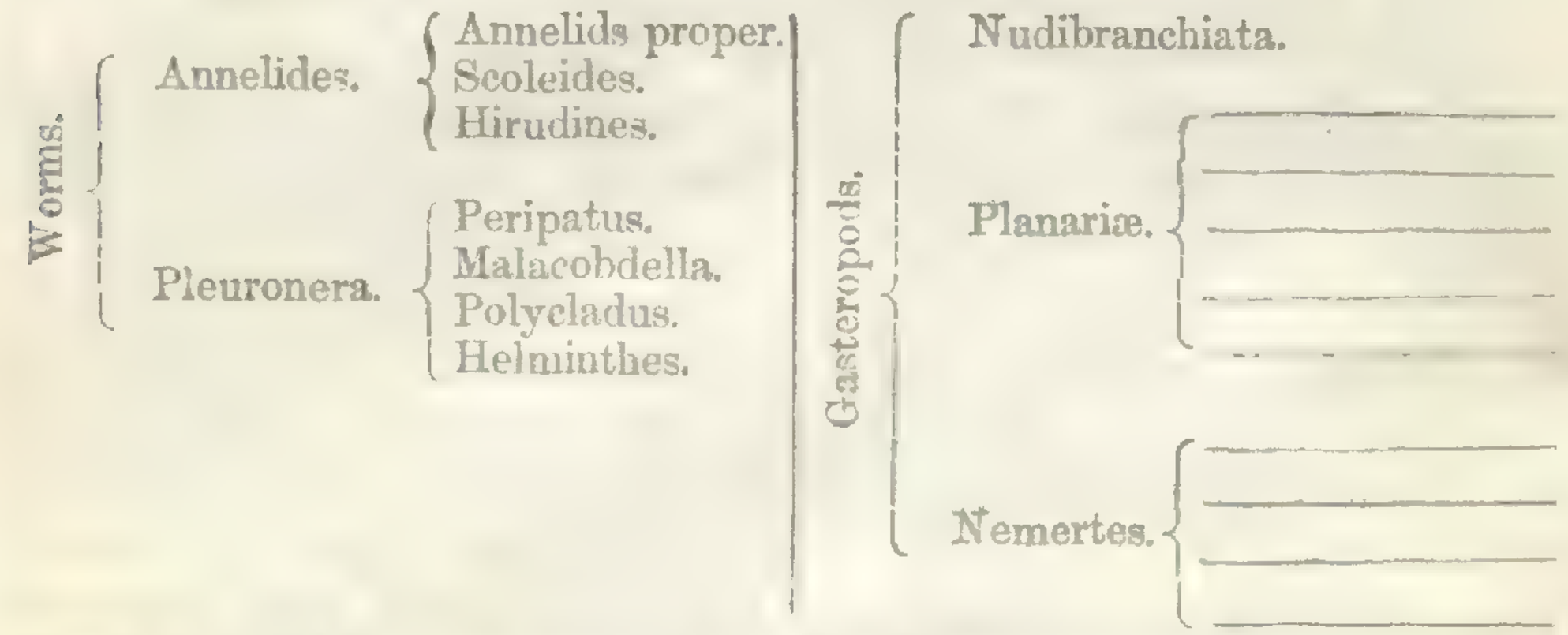
So that the connection although materially expressed, exists essentially in their immaterial essence.

VI.

I now conclude by a few words on Annelids and Gasteropods. Having withdrawn from the first of these classes a certain number of its representatives to include them among the second, it is to be expected that I should present in a synoptical manner the systematic modifications resulting from it.

If we admit the two sections of worms proposed by Milne Edwards, the Pleuronera and Annelids proper, we should place them one above the other to form a single series instead of one.

Opposite we should have the series of Gasteropods beginning with Nemertes; above these the Planariæ, then the Nudibranchiata;



What would come next to the Nudibranchiata I am not prepared to say. The series cannot go on, on that footing, for the very simple reason that embryology assigns a lower rank to all Gasteropods provided with a shell, inasmuch as Nudibranchiata, when hatched, have a shell, which they lose at an early period of their life. The attempt at forming organic series in the animal kingdom is one of the most difficult of labors, and a work of a relative value. Unless several series are established in the class of Gasteropoda, the position of Nudibranchiata in the above synopsis cannot be accounted for. I have already made the remark that Planariæ were rather parallel to Nudibranchiata than of a lower rank, finding in these two families groups of equal importance.

Respecting the serial arrangement of worms, as given above, and resting upon the morphology of their nervous system, I have also to remark, that it does not coincide with another series alluded to in a remarkable paper of late publication;* and indeed if lumbricine Annelids and Leeches are higher in their class, as I be-

* The natural relations between Animals and the Elements in which they live; by Prof. L. Agassiz. This Journal, 2d ser., vol. ix, p. 369.

lieve it, this fact corroborates the idea that the nervous system characterizes only the primary divisions. And our position would turn out to be the right one.

If instead of a single series, or several series with a starting point and an end, we construct a circle or an ellipse, and place the Gasteropods on its circumference, then the arrangement of each group would meet with less difficulty and perhaps satisfy completely the mind.

Cambridge, Mass., October, 1850.

ART. V.—*Memoir on Emery;* by J. LAWRENCE SMITH, M.D.—Second part.—*On the Minerals associated with Emery: Corundum, Hydrargillite, Diaspore, Zinc spinel, Pholerite, Epheesite* (a new species), *Emerylite* (a new species), *Muscovite, Chloritoid* (a new variety), *Black Tourmaline, Chlorite, Magnetic Oxyd of Iron, Oligiste Iron, Hydrated Oxyd of Iron, Iron Pyrites, Rutile, Ilmenite and Titaniferous Iron.*

Read before the Academy of Sciences of the French Institute, July 15th, 1850, and communicated by the author for this Journal.

Now that it has been shown that emery is found in considerable abundance in certain parts of the world,* occupying almost the position of a rock; it is useful to mention the different accidental minerals or *minerals of elimination*, that are found with emery, and what new facts have been observed with relation to them. Corundum may be first mentioned.

Corundum.—Although emery is constituted principally of corundum, the examination of this substance in its pure state, or rather in the form of those prismatic crystals which I have sometimes found in contact with emery, has brought to light several new and well established facts that could not have been satisfactorily ascertained from a mixed mineral like emery.

At *Gumuch-dagh*,† it is not difficult to find large pieces of this mineral, pure or mixed with a little diaspore and emerylite; sometimes the crystals are very distinct, under the form of six-sided prisms. The small crystals found in the cavities are sometimes terminated by a summit of six faces. The color of the corundum found in the different places alluded to in this memoir, is blue, except that of Kulah and of Adula, which is of a greenish grey. All that I have to add to what is already known of this mineral,

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* For the *First Part* of this memoir, see the last volume of this Journal, pages 354–369.

† See the *first part* of this memoir for a description of the localities, this Journal, x, 354.

relates to its *composition* and *effective hardness*; the latter was ascertained in the way already described in speaking of the emery, and it has been found to vary with the composition of the mineral. The analyses were made in the same manner as those of the emery, and the results which I have obtained are as follows:—

Localities.	CORUNDUM.		COMPOSITION.					
	Effective hardness. Sapphire 100.	Sp grav.	Water.	Alumina.	Magnetic x. iron.	Lime.	Silica	Manganese.
Sapphire of India, ...	100	4·06	——	97·51	1·89	——	0·80	——
Ruby of India, ...	90	——	——	97·32	1·09	——	1·21	——
Corundum of Asia Minor.	77	3·88	1·60	92·39	1·67	1·12	2·05	trace.
Corundum of the island of Nicaria, ...	65	3·92	0·68	87·52	7·50	0·82	2·01	——
Corundum of Asia,....	60	3·60	1·66	86·62	8·21	0·70	3·85	——
Corundum of India,....	58	3·89	2·86	93·12	0·91	1·02	0·96	——
Corundum of Asia,....	57	3·80	3·74	87·32	3·12	1·00	2·61	——
Corundum of India,....	55	3·91	3·10	84·56	7·06	1·20	4·00	0·25

The most remarkable fact ascertained by these analyses, is the presence of water in variable quantity in all varieties of the corundum except the sapphire and ruby. To me this fact has a certain value in proving that the corundum and the sapphire are formed under different circumstances and do not belong to the same geological formation. The different structure of these two species of corundum might make one suspect a difference in the condition of their formation; and this is somewhat confirmed by the results of the beautiful experiments of M. Ebelmen in making artificial corundum by subjecting alumina and borax to the heat of a porcelain furnace for many hours; circumstances under which he always obtained crystals under some of the modifications of hyaline corundum, and never as prismatic corundum. In addition to this, I remark that in my most thorough examination of the localities of emery, not the slightest trace of sapphire or ruby was found.

The quantity of water found to exist in corundum, coming from different localities, is variable, and it would appear that all other things equal, those containing the least water are the hardest. I will not insist on the slight difference between the hardness of the sapphire and ruby, having made only one experiment upon each of these minerals.

The two varieties of corundum are so evidently united by their system of crystallization, that I would not undertake to separate them on account of the presence of water in one of them, and that in variable quantity: nevertheless, the fact is important as it explains to a certain extent their differences in structure and hardness. I would remark that great pains was used to ascertain whether the water might not be due to the presence of diaspore

or some other hydrate of alumina; but after the most careful and repeated examinations, this has been decided in the negative.

Hydrargillite.—Hydrargillite is rarely met with. I have one specimen with this mineral forming the external coating of a crystal of corundum, and also a hexagonal prism of the same mineral. It was not analyzed, but its physical properties and its reactions under the blowpipe served to prove its identity with this mineral. The specimen in my possession comes from *Gumuch-dagh.*

Diaspore.—This mineral up to the present time has not occupied a very important position in mineralogy, and has been found only in two or three localities. In the course of this article, I hope to show that it plays a somewhat important part in the emery and corundum formations. Before my attention was drawn to the minerals, first discovered by M. Lelievre, it was studied by M. Dufrenoy, on that coming from Siberia, and by M. Haidinger on the diaspore of Schemnitz. Before going farther I would remark, that the gangue of the latter which has been described as analogous to steatite, was found by me not to be such, but a hydrated silicate of alumina, similar to one found with the emery of Naxos.*

To the localities of diaspore already known, I have to add those of *Gumuch-dagh* and *Manser* in Asia Minor, and the islands of *Naxos*, *Samos*, and *Nicaria*, in the Grecian Archipelago; and there is reason to suppose that this mineral will be found in almost every corundum locality. I have already found it on crystals of corundum from China.†

In examining the emery formations, one of the first things that struck my attention was the existence of diaspore and corundum together, then observed for the first time. The same year, M. Marignac discovered it in the limestone of St. Gothard, along with the well known crystals of corundum that exist there. Having found the diaspore under these new circumstances it has been examined with much attention.

At Gumuch-dagh the diaspore is found in flattened and rounded prisms with the surface streaked with lines that afford by reflected light an iridescence. Crystals with perfect summits are rarely found, and during two or three days examination on the place I found only five small crystals with one of the summits perfect, they were however, very beautiful and finer probably

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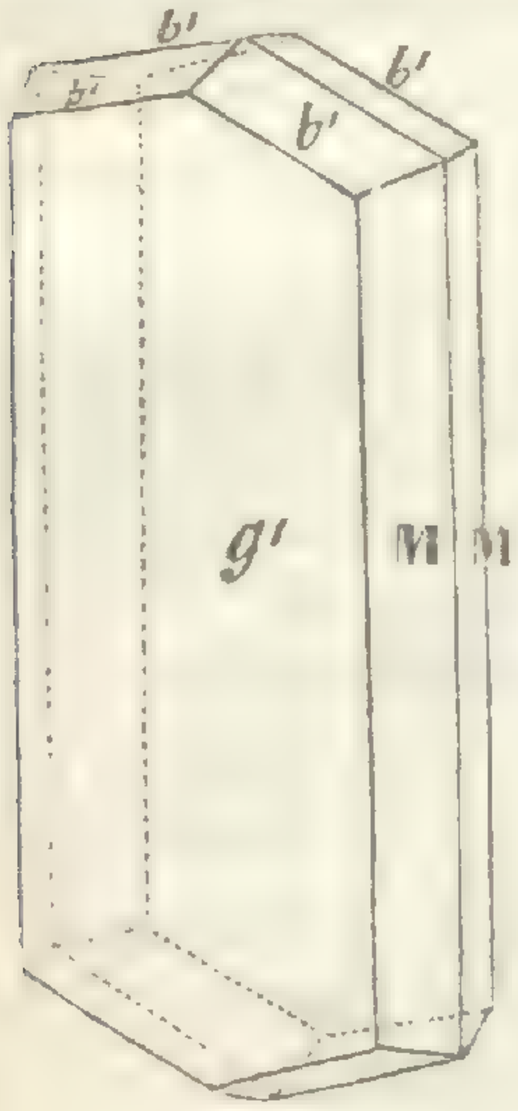
* The gangue of the Schemnitz diaspore has been examined by Hutzelmann, see this Journal, [2], x. 247, and Pogg. Ann., lxxviii. 575, who makes it to contain three distinct hydrates of alumina; but this fact cannot be considered as sufficiently established. One of these hydrates is named *Dilinite*, and another is near Agalmatolite.

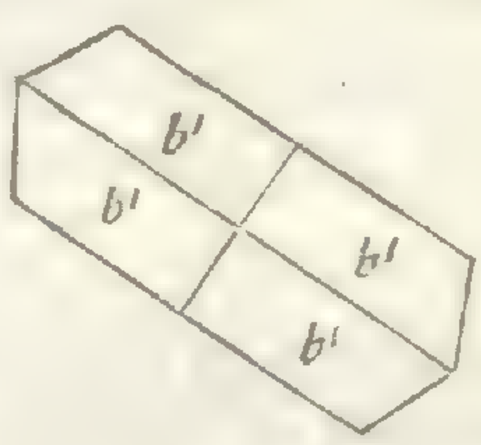
† Prof. C. U. Shepard has found diaspore with topaz at Trumbull, Conn.

than any yet known. Not wishing to lose so favorable an occasion to verify the crystallography of diaspore, I requested M. Dufrenoy to undertake the measurement of the angles, and it is to this able professor that we are indebted for the crystallographic results here given.*

1.



1 *a*.



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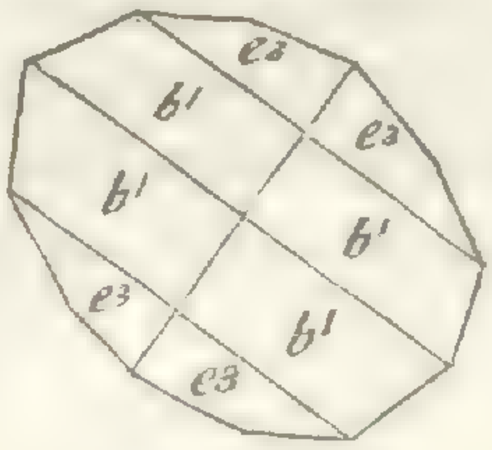

2.

The crystals are elongated needles crossing each other in all directions like an acicular variety of arragonite from the Vosges. They resemble small crystals of topaz in lustre and in the disposition of the vertical striæ on the faces *g*. Their color is yellowish white. They are strongly dichroitic, the summits under certain inclinations appear black as if the light was completely polarized. The cleavage is very easy parallel to the face g^1, and it is this cleavage that gives a lamellar structure to that diaspore which is not in the form of needles. This cleavage notwithstanding its facility does not expose surfaces that reflect with great accuracy; it is the only angle which offers the difference of a half degree; repeated measurements of the other angles never varied more than four minutes. The pearly lustre of the cleavage in connection with its striated character are the causes of this difficulty which at first sight would not appear to exist, only becoming evident when the angle is examined.

The crystals, very much flattened parallel to the face g^1, are represented by figures 2 and 3; the face g^1 does not exist, being replaced by three series of faces *g*, the angles of which could not be measured, but the almost absolute identity of these crystals with those of St. Gothard, which M. Marignac first described,

* Three of the crystals measured are in the Cabinet of the School of Mines and Garden of Plants at Paris.

The second crystal above is nearly as thin as the first, although represented thicker in order to show well all the planes.

authorizes one to suppose that they are represented by the crystallographic signs g^2 and $g\frac{5}{3}$. The faces M and those of the summit have a very bright lustre. The primitive form of the diaspore is undoubtedly a right rhombic prism of 130° 2′; the fact that the base is horizontal, is shown by the identity of the angles of the faces b^1 on the anterior faces M, and the faces b^1 on the posterior faces of the same. This position is verified in seeking for the angle of the edge b^1 on M, which ought to be a right angle; in fact the calculation of a spherical triangle composed of the faces M, b^1 and g^1, of which all the angles of incidence were measured, gave for this edge 90° 2′ 30″, which differs from a right angle by only two minutes and a half.

The following table is made up of the measurements of the angles of the diaspore of Gumuch-dagh (near Ephesus) by M. Dufrenoy, of that of St. Gothard by M. Marignac, and of that of Schemnitz by M. Haidinger, also the measurement of some angles of the hydrated peroxyd of iron of Cornwall, by M. Dufrenoy, which are here given to show an interesting connection, first pointed out by M. de Senarmont, and which consists in the isomorphism of diaspore and the hydrated oxyd of iron. Thus while the peroxyd of iron or oligiste iron is isomorphous with alumina or the corundum, the hydrates of the same oxyds are isomorphous.

	Diaspore of St. Gothard, *Marignac.*	Diaspore of Schemnitz, *Haidinger.*	Diaspore of Gummeh-dagh near Ephesus, *Dufrenoy.**	Hydrated Oxyd of Iron, of Cornwall, *Dufrenoy.*
M : M	130°	129° 54′	130° 2′	130° 57′
M : b_1	.....	.....	125° 17′	
M : b_1 (posterior faces),	.....	.....	125° 18′	
M : g_1	115°	.....	114° 58′	
b_1 : g_1	104° 12′	.....	104°	
b_1 : b_1	151° 36′	151° 36′	151° 35′	
b_1 : b_1 (posterior faces),	.....	.....	151° 33′	151° 34′
b_1 : b_1 (opposite faces),	116° 38′	.....	116° 18′	
b_1 : c_3	.....	.....	167° 6′	
g_1 : g_2	144° 40′	.....		
g_2 : g_2	145° 40′	.....		
i : i	126° 12′	.....	.....	126° 20′
g_1 : i	116° 56′	.....	.....	116° 55′
$e^{\frac{1}{2}}$: $e^{\frac{1}{2}}$	117° 46′	.....	.....	117° 10′

I have found crystals of diaspore in hydrated oxyd of iron, the needles traversing the oxyd in all directions. There is a specimen in my possession composed of a small crystal of diaspore, surrounded by a kind of scabbard of crystallized göthite; one of the summits of the crystal is exposed. In breaking the oxyd of iron which contains these crystals, they become detached, leaving on the oxyd an impression with a very brilliant surface.

* The values of these angles are just as given by the goniometer without any correction by calculation.

The diaspore of Gumuch-dagh is also found, of a lamellar structure, but very rarely; that of Naxos, Nicaria and Samos are all lamellar. Yet of all the specimens that I have collected none offer so much interest as those composed of diaspore imbedded in corundum; here we see the two minerals passing one into the other, without being able, in many places, to distinguish the line of separation, so imperceptible is the gradation. After what has been said in respect to corundum, it is not astonishing to see this connection of alumina more or less hydrated with a hydrate of alumina of definite composition.

After a knowledge of this fact one might seek to explain the existence of water in corundum, by the intimate mixture of diaspore with this mineral; if this be the case, the crystal of corundum from the Carnatic, which gave me three per cent. of water, must contain twenty-three per cent. of diaspore, although neither the eye nor microscope could detect its presence.

As to the properties of diaspore, I have nothing to add to what has already been published on the subject, except that the specimens I examined do not decrepitate to the same extent as that of Siberia. Its specific gravity is 3·45 and hardness above 7. The following analyses were made, the mineral being attacked with the bisulphate of soda. They afford the formula, $\ddot{A}l\,\dot{H}$.

Localities.	Silica.	Alumina.	Lime.	Oxyd of Iron.	Magnesia.	Water.
Gumuch-dagh,.....	0·67	82·20	0·41	1·20	*trace.*	14·52
Gumuch-dagh,.....	0·82	83·12	*trace.*	0·66	*trace.*	14·28
Naxos,.....	0·26	82·94	0·35	1·06		14·81

Zinc Spinel.—I possess a single specimen of this spinel in chloritoid on a piece of emery from Gumuch-dagh: it is in octahedral crystals agglomerated, of a dark emerald green color; the quantity being small I have been prevented from making an exact analysis. The quantity of oxyd of zinc appears to be from thirty to forty per cent.

Pholerite.—A mineral, resembling pholerite in composition, has been found with the emery of Naxos associated with emerylite. It is white, lamellar, and somewhat crystalline, sometimes grey. It is soft to the touch like steatite, infusible before the blowpipe, and when heated with nitrate of cobalt becomes strongly colored blue. It is scratched with the nail, and has a specific gravity of 2·564. Its composition is identical with the pholerite of Guillemin, also with the mineral forming the gangue of the diaspore of Schemnitz. For analysis it was decomposed with carbonate of soda. It afforded:—

		Pholerite of Guillemin.	Gangue of diaspore of Schemnitz—Smith.
Silica,	44·41	42·93	42·45
Alumina,	41·20	42·07	42·81
Lime,	1·21		*trace* and mag. *trace.*
Water,	13·14	15·00	12·92

This corresponds to the following formula, $\ddot{S}i\,\ddot{A}l+2\dot{H}$, but it is a question whether or not we should consider the water as existing in any definite proportion, and whether or not they did not all contain more water when first taken from their localities. These hydrated silicates of alumina are numerous, and bear various names, but it is doubtful if many of them are entitled to much consideration as distinct species.

Ephesite, (a new species.)—This silicate is found with the emery of Gumuch-dagh and occurs on specimens of magnetic oxyd of iron. It is of a pearly white color, and lamellar in structure; cleavage difficult. It scratches glass easily, and has a sp. grav. of from 3·15 to 3·20. Heated before the blowpipe it becomes milk-white, but does not fuse. At first sight it might be taken for white disthene. It is decomposed with great difficulty by carbonate of soda even with the addition of a little caustic soda. I used also very successfully in the analysis the bisulphate of soda either in attacking the mineral from the commencement, or in operating first with carbonate of soda, and then acting on the part not decomposed with bisulphate of soda. The alkalies were separated by means of hydrofluoric acid.

Silica,	31·54	30·04
Alumina,	57·89	56·45
Lime,	1·89	2·11
Protoxyd of iron,	1·34	1·00
Soda with a little potash,		4·41
Water,	3·12	3·06

This corresponds very nearly to the formula

$$\dot{R}^2\,\ddot{S}i+5\ddot{A}l^2\,\ddot{S}i+4\,\dot{H}.$$

	Atoms.	At. weight.	Pr. ct.	Oxygen ratio.
Soda,	2	781·6	7·08	1
Silica,	6	3400·2	30·77	9
Alumina,	10	6416·2	58·08	15
Water,	4	450	4·07	2

This mineral has been designated *Ephesite* because of its occurrence at the emery locality near the ancient city of Ephesus.

Emerylite, (a new species.)—This mineral which I have designated by the name of Emerylite is a new species belonging to the family of micas. I have already published a note indicating its existence,* but have reserved for the present time a complete description of it.

I first discovered this mineral with the emery of Gumuch-dagh in Asia Minor, and subsequently in that of Manser, the islands of Naxos and Nicaria, and also with the emery of Siberia.

* See this Journal, 2nd ser., vii, 285, 1849.

Its connection with all the emerys that have come under my observation except that of Kulah, induced me to call it *Emerylite.* When I announced this discovery to Prof. Silliman, Jr., he hastened to examine the minerals coming from the corundum localities of the United States, and has succeeded in finding the emerylite with the corundum of several localities.* The specimen from Siberia on which I found this mineral is in the collection at the Garden of Plants at Paris, and I have also reason to think that I have found it with the corundum of China.

The emerylite is lamellar like mica, the plates are easily separated, and possess a little elasticity. Sometimes it is in the form of a mass composed of very small pearly scales, which are very friable, resembling some species of talc. The plates are commonly convex and concave, grouped in such a manner as to form a triangular prism. I have also found it massive with a micaceous structure, but with an irregular fracture; the aspect of this variety is waxy: it comes from Gumuch-dagh. The crystalline form of this mineral is difficult to determine, but if we are permitted to judge from the streaks on the surface, and the imperfect cleavage in two directions, it would appear to belong to an oblique rhombic prism.

Its color is white and lustre silvery; the hardness taken on a specimen from the island of Nicaria is from 4 to 4·5. The sp. grav. taken on ten specimens varies from 2·80 to 3·09; this difference is not remarkable in a lamellated mineral. That which gave me the greatest specific gravity contained some small specks of titaniferous iron visible to the eye. Its optical properties have not been examined, for the want of a transparent piece of sufficient size and thickness. This mineral is not attacked by the acids; heated before the blowpipe it emits a bright light and melts with great difficulty on the edges, which assume a blue color if touched with the nitrate of cobalt and reheated. Heated in a tube it furnishes water frequently having an acid reaction due to fluoric acid.

The composition of several specimens subjected to analysis is as follows:—

Localities.	Silica.	Alumina.	Lime.	Oxyd iron.	Magnesia.	Potash & soda.	Water	Manganese.
Gumuch-dagh, ...	29·66	50·88	13·56	1·78	0·50	1·50	3·41	——
Island of Nicaria, ...	30·22	49·67	11·57	1·33	*trace.*	2·31	5·12	——
" "	29·87	48·68	10·84	1·63	*trace.*	2·86	4·32	——
Island of Naxos, ...	30·02	49·52	10·82	1·65	0·18	1·25	5·55	——
" "	28·90	48·53	11·92	0·87	not estimat'd	not estimat'd	5·08	——
" "	30·10	50·08	10·80	not estimat'd	"	"	4·52	——
Gumuch-dagh, ...	30·90	48·21	9·53	2·81	"	"	4·61	——
"	31·93	48·80	9·41	1·50	"	2·31	3·62	*trace.*
Siberia, ...	28·50	51·02	12·05	1·78	"	not estimat'd	5·04	——

* See this Journal, viii, 379, and Dana's Mineralogy, pp. 362 and 689.

The oxyd of iron may be regarded as an impurity which exists between the plates of the mineral. The composition of the emerylite is represented by

	Atoms.	At. Weight.	Pr. ct.	Oxygen ratio.
Lime,	2	700·	13·48	2
Silica,	3	1700·1	32·74	9
Alumina,	4	2566·5	49·44	12
Water,	2	225·	4·34	2
		5191·6		

Formula, $\dot{R}^2\,\ddot{S}i + 2\dot{A}l^2\,\ddot{S}i + 2\dot{H}$,

As is seen, the specimens examined came from four distinct localities, and were all taken under different circumstances; yet their analyses accord perfectly, and also agree with those of the United States coming from Village Green and Unionville of Pennsylvania, and Buncombe County, North Carolina.*

Localities.	Silica.	Alumina.	Lime.	Magnesia.	Potash & soda.	Water.		
Village Green,	32·31	49·24	10·66	0·30	2·21	5·27	=100	*Craw.*
"	31·06	51·20	9·24	0·28	2·97	5·27	=100	*Craw.*
"	31·26	51·60	10·15	0·50	1·22	4·27	=100	*Craw.*
"	30·18	51·40	10·87	0·92	2·77	4·52	=100·46	*Craw.*
Unionville,...	29·99	50·57	11·31	0·72	2·47	5·14	=100·10	
"	32·15	54·28	11·36	0·05	not estimat'd	0·50	Fe *trace,*	*Hartshorne.*
Buncombe Co..	29·17	18·40	9·87	1·24	6·15	3·99	HF 2·03 =100·80	*Silliman, Jr.*

My analyses were made in the ordinary way, only with more carbonate of soda than is usually employed. The alkalies were separated either by means of hydrofluoric acid or by carbonate of lime, which is preferable to the carbonate of baryta for the decomposition of the silicates.

It is seen that potash and soda are present in small quantities in all the specimens. The composition of this mineral is remarkable for the large proportion of alumina present; but when we look at its origin it is not astonishing to find a silicate of alumina with a small amount of silex.

I regard emerylite as a mineral of elimination from emery, the result of an effort by which the corundum in its formation purifies itself. It is not remarkable that from the mass in which the corundum crystallizes, the silica finding itself in presence with an excess of bases, combines with as large a quantity as its affinity will admit of. In speaking of the formation of emery, I have already alluded to a nodule in my possession that exemplifies this in a very exact manner.

* See Dana's Mineralogy, 3d edition, p. 362.

Notwithstanding the recent discovery of emerylite there is no other species of mica that can be considered so well established as this mineral, or so constant in its composition. Up to the present time this mineral has not been found except with emery or corundum, which frequently contain it in the interior of the mass as well as on the surface. Some emerys contain it in such quantity that it has the aspect of gneiss, as I have already said with reference to certain specimens from Nicaria.

The most beautiful specimens of emerylite come from Naxos; and as the blocks of emery from this island frequently contain it, there will be no difficulty in procuring specimens for cabinets. It is often mixed with diaspore.

Mica, (Muscovite?)—This mica is found on all the emerys which I have examined, but especially on that coming from Kulah. It is always in small plates on the surface of the emery. The analyses of four specimens are as follows:—

Localities.	Silica.	Alumina.	Lime.	Oxyd of iron.	Magnesia.	Pot'h with little soda.	Water.	Manganese.
Gumuch-dagh, ...	42·80	40·61	3·01	1·30	*trace.*	not estimated.	5·62	*trace.*
Kulah, ...	43·62	38·10	0·52	3·50	0·25	7·83	5·51	*trace.*
Kulah, ...	42·71	37·52	1·41	2·32	*trace.*	not estimated.	5·95	*trace.*
Island of Nicaria, .	42·60	37·45	0·68	1·70	*trace.*	9·76	5·20	*trace.*

The composition is very nearly that of the muscovite or Muscovy glass, and until farther examination, I shall retain it under that species, as particular care should be exercised in making new species among the micas.

Chloritoid, (a new variety of this mineral.)—It is found with the emery of Gumuch-dagh in considerable abundance. Its structure is lamellar, cleaving without much difficulty, and the surfaces exposed are always very brilliant. In thin fragments it transmits the light and appears of a dark green color. The powder is greenish grey. Its hardness is 6, and specific gravity 3·52. Heated in the flame of the blowpipe it loses water, and becomes brown from the absorption of oxygen but does not melt. When heated without being in contact with the air it loses its brilliancy, and acquires the aspect of scales from the blacksmith's forge.

This mineral is attacked by the strong acids but is only completely decomposed by sulphuric acid. Melted with four or five times its weight of carbonate of soda it is rendered easily soluble in hydrochloric acid. Great precaution was taken to see that nothing but perfectly pure chloritoid was submitted to analysis, and the possession of well crystallized specimens enabled me to do this without much difficulty.

The method of analysis, was to break the mineral in small fragments, to place it in a small platinum crucible, which was introduced into an earthen crucible and surrounded by pulverized quartz: in one word, I pursued the same method as that for estimating the water in emery. For the other ingredients, a new portion was taken, pulverized finely, and attacked either by concentrated sulphuric acid or melted with carbonate of soda, and afterwards dissolved in hydrochloric acid with the addition of a little nitric acid evaporated to dryness, and treated with dilute hydrochloric acid. The liquid separated from the silica is treated with an excess of caustic soda, and the filtered liquid is neutralized by hydrochloric acid and the alumina precipitated by carbonate of ammonia.

The contents of the filter which are essentially peroxyd of iron, are placed in a capsule, dissolved by hydrochloric acid, heated and precipitated by ammonia and thrown on a filter. From the filtered solution the lime and magnesia are separated in the ordinary way. The peroxyd of iron remaining on the filter after being well washed and dried, is weighed and decomposed in a current of hydrogen gas. To the oxyd thus reduced, nitric acid diluted with thirty times its weight of water is added, and digested at 100° to 120° C. for about an hour, stirring frequently, when if the iron has been thoroughly reduced it will be taken up by the acid, and a little alumina left which is weighed and added to the first portion. Ordinarily I never have found more than from one to two per cent. of alumina with the oxyd of iron. Care must be taken to decompose the iron completely, as otherwise the iron will not be entirely taken up by the acid. The mineral thus analyzed afforded as follows:—

	Silica.	Alumina.	Protox. of iron.	Water.	Lime.	Magnesia.	Titanic acid.	Manganese.	Potash & soda
Decomposed by sulphuric acid,	24·10	39·8	27·55	6·5	not estimat'd	not estimat'd	not estimat'd	not estimat'd	0·30
Decomposed by carb. soda, . . .	23·94	39·52	28·05	7·08	0·45	0·80	*trace.*	0·52	——
Decomposed by carb. soda, . . .	23·20	40·21	27·25	6·97	0·83	0·95	*trace.*	not estimat'd	——

These analyses correspond to the following composition.

	Atoms.	At. weight.	Pr. ct.
Silica,	2	1133·40	23·87
Alumina,	3	1925·88	40·57
Protoxyd of iron,	3	1350·00	28·44
Water,	3	337·50	7·12

The most probable formula is

$$\dot{Al}^2\,\bar{Si} + \dot{Fe}^2\,\bar{Si} + 3\dot{H}.$$

The minerals which are brought under this species are the chloritspath or chloritoid of the Ural, the Sismondine of St. Marcel and the Masonite of Rhode Island; their analyses and formulæ are as follows:—

	I.	Oxygen.	II.	Oxygen.	III.	Oxygen.	IV.	Oxygen.	V.	Oxygen.	VI.	Oxygen.
Silica,.....	27·48	6	24·40	2	24·1	9	28·27	6	25·18	5	23·91	2
Alumina,..	35·37	6	45·17	3	44·2	15	32·16	6	33·61	6	39·52	3
Protox. of iron,....	27·05	3	30·29	1	23·8	4	33·72	3	35·31	3	28·05	1
Magnesia,..	4·29											
Water,....	6·95	3	....	..	7·6	5	5·00	2	5·88	2	7·08	1

I. Chlorite spar or Chloritoid of the Ural by Bonsdorff. $(\dot{Fe},\dot{Mg})^3\ddot{Si}+\ddot{Al}^2\ddot{Si}+3\dot{H}$.

II. Chlorite spar of the Ural, Erdmann. $\dot{Fe}^3\ddot{Al}+2\ddot{Al}\ddot{Si}$.

III. Sismondine of St. Marcel, Delesse. $\dot{Fe}^4\ddot{Si}^3+5\ddot{Al}\dot{H}$.

IV. Masonite of Rhode Island, Whitney. $\dot{Fe}^3\ddot{Si}+\ddot{Al}^2\ddot{Si}+2\dot{H}$.

V. Chlorite spar according to Rammelsberg requires, $3\dot{R}^3\ddot{Si}+2\ddot{Al}^3\ddot{Si}+6\dot{H}$.

VI. Chloritoid of Asia Minor, J. L. Smith. $\ddot{Al}^3\ddot{Si}+\dot{Fe}^3\ddot{Si}+3\dot{H}$.

This mineral is found very abundantly with the emery of Gumuch-dagh; it covers the surface of the blocks, and sometimes enters largely into the substance of the emery. It is easy to see from the composition of this mineral, that it is formed by elimination from the mass of emery at the time of its consolidation, which by this means tends to purify itself. The nodule of which I have already spoken under the head of emery and of emerylite goes to sustain this view of the question.

On the emery of the other localities, I have not found this chloritoid. Its composition is not in perfect accordance with the known varieties of chloritoid, and differs from Sismondine (which it approaches most in composition) by its imperfect solubility in hydrochloric acid.

Black Tourmaline.—This mineral is found abundantly with the emery of Naxos, and also in small quantities with that of other localities. It appears to have replaced the chloritoid that is found so abundantly with the emery of Gumuch-dagh.

The crystals are found agglomerated on the surface, and also disseminated in the interior of the emery. This mineral like the last is strongly basic, containing a little more than thirty per cent. of silica.

Chlorite.—With the emery of Gumuch-dagh we find a chlorite. It is in compact masses composed of an agglomeration of small crystalline plates, and contains octahedral crystals of magnetic oxyd of iron. Analysis gives as its composition,

Silica,	27·20
Alumina,	18·62
Protoxyd of iron,	23·21
Magnesia,	17·64
Water,	10·61

It is identical with the chlorite of *Mont des sept-Lacs* which gave M. Marignac,

Silica,	27·14
Alumina,	19·19
Protoxyd of iron,	24·76
Magnesia,	16·78
Water,	11·50

It is the same as the chlorite of *St. Christophe* and the ripidolite of *Rauris* and of *St. Gothard.* The formula given by von Kobell is,

$$2\dot{M}g\,\ddot{A}l+3(\dot{M}g\,\dot{F}e)^{3}\,\ddot{S}i+6\dot{H}.$$

Magnetic Oxyd of Iron.—This is found with the emery of every locality. It enters into the composition of the emery itself and is also found on the surface in regular octahedral crystals. We find it frequently massive and of strong polarity. That of Gumuch-dagh contains a trace of titanic acid.

Oligiste Iron.—It is associated with all the emerys, and sometimes enters into their composition. It is also found in detached masses, either amorphous or as crystallized specular iron.

Hydrated Oxyd of Iron.—This oxyd of iron is not unfrequently found with emery, covering the surface. It is found with pyrites having resulted from the decomposition of this mineral.

Iron Pyrites.—Pyrites is found principally with the emery of Gumuch and Nicaria. At the latter locality it is in small crystals in the interior of the mass. At Gumuch it is principally on the surface but much less abundant than at Nicaria.

Rutile.—This oxyd of titanium is found with the emery of Gumuch-dagh and of Kulah, where I obtained some large detached crystals. I have also a specimen, with it in small crystals on diaspore attached to emery from Gumuch-dagh.

Ilmenite.—It has been found on the gangue of the emery of Kulah in minute crystals, of the usual form of this mineral.

Titaniferous iron.—Titaniferous iron is found with almost all the varieties of emery that I have examined, but I have analyzed none but that associated with the emery of Nicaria. Care being

first taken to see that it was anhydrous, one gramme of it was calcined in a current of oxygen and it augmented ·019, which indicated the presence of ·171 gramme of protoxyd of iron, and corresponds to ·190 gramme of peroxyd of iron; the same portion then decomposed by a current of hydrogen gas and the loss sustained was equal to ·222 gramme of oxygen, which corresponds to ·740 gramme of peroxyd of iron; deducting from this the quantity of peroxyd equal to the protoxyd (·171) contained in the mineral, we have ·550 gramme for the quantity of peroxyd present. The mass reduced by hydrogen was treated with hydrochloric acid, and the part not dissolved (·230 gramme) was titanic acid with a little alumina. The acid solution contained ·010 lime, and a trace of alumina. The titanic acid was examined as to its purity and was found to contain no silica, and only a trace of alumina. The result of the analysis is,

Protoxyd of iron, . . .	17·10
Peroxyd of iron, ...	55·00
Titanic acid, ...	23·01
Lime, ...	1·00
Alumina, . . .	a little, not estimated.

This titaniferous iron corresponds in composition to the Washingtonite of Prof. Shepard as analyzed by M. Marignac, and to the titaniferous iron of Arendal analyzed by M. Mosander. Its sp. grav. is 4·78.

There are still two or three minerals that I have found associated with emery, but their specific characters have not been well established, on account of the difficulty of obtaining enough in a state of sufficient purity for analysis.

The study of these accidental minerals in contact with emery has led to several general conclusions which have been mentioned under the description of the different species; and now I do not risk much in saying, that the hydrates of alumina, as diaspore,—as well as the silicates, as emerylite, chloritoid and tourmaline,—and the minerals of iron, as magnetic, titaniferous iron, &c,—will be found almost everywhere with the emery and corundum.

My labors on this subject are thus terminated, and it is to be hoped that the examination of the emery of Asia Minor has served to elucidate the geology and mineralogy of this substance, until now but little known except in its uses.

ART. VI.—*On the Velocity of the Galvanic Current in Telegraph Wires;* by B. A. GOULD, Jr., in a Report to Prof. A. D. BACHE, LL. D., Superintendent of the U. S. Coast Survey.

DEAR SIR,—You did me the honor, last spring, to place at my disposal the materials derived from the telegraph experiments of the Coast Survey during the evening of Feb. 4, 1850, with an invitation to investigate them independently. I have accordingly devoted some labor to their discussion, and with your permission, will state the conclusions to which I have been conducted, in the same didactic form in which they were orally presented to the late meeting of the American Association held under your presidency at New Haven.

It may be permitted me, however, to add that I submit them with diffidence, for various reasons—not the least of which is that some of these conclusions are at variance with the known views of scientific friends, on whose judgment I place great reliance.

As but few have probably followed all the investigations on the subject, a large proportion of which have been published within a twelvemonth, it may be well for me to recapitulate to some extent what has already been done. Thus before detailing the results of the experiments of Feb. 4, I will endeavor to state the position of the theory before the discussion of those results. A peculiarity of the question consists in its intimate relation with the theory of electrical force, and the nature of conduction. This relation is so intimate as to render it almost impossible to discuss the subject without making use of phraseology derived from hypothesis. This may however be done with perfect safety—so long as we remember that such phraseology is only used for convenience of expression. If then I avail myself of such expressions as "electric current,"* for instance, "circulation," "wave," or similar phrases derived from hypothesis, plausible or otherwise, I will ask to be considered as using the terms in a metaphorical rather than in a literal sense. A simple idea may thus be expressed in a single word, while a carefully guarded circumlocution would otherwise be necessary, to distinguish "between the transmission of the effect and of the supposed fluid by the motion of whose particles that effect is produced."†

The ingenious experiment‡ of Prof. Wheatstone in 1834, tended to confirm the general opinion previously existing, that the velocity with which the electricity was transmitted by a metallic conductor was so enormous—so immense, indeed, compared with

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* Faraday, Researches, i, pp. 81, 148.
† Id., i, p. 526.
‡ Phil. Trans., 1834, p. 583.

all other velocities known to us, excepting that of light—as to warrant the assumption of our incapacity to determine it. On this account, Wheatstone's elegant experiment obtained for its author the more distinction, and for his results the greater confidence. One of these results, as announced by him, was, that the velocity of electricity through the copper wires used, was indeed appreciable,—but exceeded that of light through the planetary space,* that it could not be less than 288,000 miles in a second, while light traverses about 196,000 during the same time.

The telegraphic observations, instituted under the immediate direction of Mr. Walker, by the U. S. Coast Survey, for determining the differences of longitude between remote stations in the United States, led to a very unexpected result,—viz.: that to obtain the greatest harmony among the several observations, a small correction must be introduced, depending on the relative distances between the telegraphic stations. No explanation of this phenomenon offered itself, excepting the hypothesis, suggested† by Walker, and communicated by yourself to the Am. Phil. Society in March, 1849, that the time elapsing during the passage of the signals between remote stations was much more considerable, and the velocity consequently less than had been before imagined.

Since Walker's results were first published, the subject has engaged the attention of numerous astronomers and physicists in Europe and America, among whom Mitchel, Fizeau and Steinheil are conspicuous. The subject belongs in itself far more properly to the domain of physics than to astronomy, but its special bearing upon the problem of longitude and the manner in which it has forced itself upon the consideration of astronomers have made it incumbent upon them to enter into a full discussion of the subject.

While in Washington in the month of February last, I accepted with pleasure an invitation from Mr. Walker to take part in an experiment on a very large scale, for which he had been long engaged in making preparation in behalf of the Coast Survey, and from which he anticipated results so ample as to put an end to the controversy. The Seaton Station of the Survey in Washington, north of the Capitol, and the city of St. Louis were connected on the 4th February, in one colossal galvanic circuit, and but for the damage occasioned by a storm on the same day, the circuit would have extended even to Dubuque in the territory of Iowa, a distance of some 1500 miles.

The wires of that line of telegraph, and of all I think which have been used in the experiments for velocity (with a single exception), are of iron, and of the size known in trade as No. 9,

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* Phil. Trans., 1834, p. 591.

† Proc. Am. Phil. Soc., v. pp. 76. Astr. Nachr., xxix, 54.

being about three millimeters in diameter. We have every reason for believing that the velocity with which electricity is conducted, varies* with the conducting power of the medium, and should therefore naturally anticipate that this velocity would be found greater in copper than in iron. Wheatstone used in his experiment copper wire $1'''''\cdot7$ in diameter. Now the conducting power of iron is according to Lenz,† Riess,‡ and Pouillet.§ who determined it by different methods, less than $\frac{1}{6}\frac{8}{0}$ that of copper at 0°·C. And when we take this circumstance into consideration, it appears a sufficient ground for believing that the results of Walker and Wheatstone are not inconsistent with each other—even without reference to the fact that the one used the galvanic current, and the other machine-electricity of the highest possible tension.

Walker's first results,‖ derived from the longitude operations of the Coast Survey, led him to the opinion that the velocity with which the signals passed between Cambridge and Washington on the night of Jan. 23, 1849, was 18,690 miles a second, with a probable accidental error of 1000 miles.

On the night of Oct. 31, 1849, a series of experiments was made for the express purpose of determining the time needed for the transmission of signals. The results are published¶ in No. 7 of the *Astr. Journ.*, with a detailed account of the methods which he used, and an analytical investigation of the effects of those circumstances which could interfere with the accuracy of his results. The measurements of all the registers gave him for the velocity on that night 16,000 miles a second,—differing less than 1900 miles from his previous result and tending in general to confirm it. The final result at which he arrived was the general theorem,—that a signal given by breaking or closing the galvanic circuit at any point, was observed at other points on the circuit after intervals proportionate to their distance from the place where the signal was made,—and corresponding to a velocity of from 16.000 to 19,000 miles a second. Later experiments with the chemical telegraph are described** in No. 14 of the *Astr. Journ.*, and gives a still less velocity.

Prof. Mitchel, of the Cincinnati Observatory, dissents from the view taken by Mr. Walker, and attributes the results obtained by him to the effect of various sources of error and uncertainty in the methods which Walker has used. He devised a special and very curious apparatus for investigating the question,—and with the ingenuity and mechanical skill for which he is so eminent,

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* Faraday. Researches, i, p. 423. † Pogg. Ann., xlv, p. 109. ‡ Id., xlv, p. 20.
§ Pouillet-Müller, Lehrb. der Physik, ii, p. 186.
‖ Proc. Am. Phil. Soc., v, p. 74. ¶ Astr. Journ., i, p. 49.
** Astr. Journ., i, p. 105.

constructed it at the Cincinnati Observatory, and made a large series of interesting experiments on the telegraph line between Cincinnati and Pittsburg.* Prof. M.'s view of the matter is, that after a signal is given by closing or by breaking the galvanic circuit,—an appreciable time elapses before this signal is communicated to any other station—and that it is then received by all simultaneously. He considers this in connection with the details of his experiment to indicate that two fluids circulate in opposite directions between the poles of a battery,—but that neither makes its influence perceptible until complete circulation of each† has taken place from pole to pole. The velocity of this circulation Prof. Mitchel infers to be about 30,000 miles a second.

Finally, Fizeau and Gounelle, in a paper published‡ last April, in the *Comptes Rendus* of the French Academy, express a want of confidence in Walker's results, and describe experiments of their own, made on a circuit of 374 miles—a distance which they characterize as enormous, although the circuit used in the first Coast Survey experiments of Jan., 1849, extended through 550 miles of wire between Cambridge and Washington, and terminated at stations 380 miles apart in a geodetic line. These gentlemen used a method totally different from either Walker's or Mitchel's, and found that it gave them 62,000 miles a second, as the velocity in an iron wire, 4 millimeters in diameter, and 110,000 as the velocity in a copper wire, $2'''''\cdot5$ in thickness. Their method is not unlike that of Jacobi's experiments§ at St. Petersburg in 1838 for the determination of the time necessary for the development of a galvanic current. The experiments appear to have furnished no data for an inference as to whether a signal is necessarily communicated to the several parts of the circuit after intervals proportionate to the distance, or not.

Such is the present state of the theory, to the best of my knowledge,—and it will be observed that the views in the most fundamental points are far from unanimous. Still greater differences of opinion exist in regard to the more special questions.

The experiments of Feb. 4, have, it appears to me, furnished ample materials for arriving at a decision on very many of the vexed points, and without farther introduction, I shall proceed to consider the nature of those experiments, the sources of error, and the amount of error introduced by them. Mr. W. has already done this very elegantly in the memoir‖ to which I have referred; but I will also briefly consider the subject here. It will then be more easy to enunciate the questions, to which a discussion of the

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* Astr. Journ., i, p. 13. *Astr. Nachr.*, xxx, p. 325.
† Faraday, Researches, i, pp. 518, 520, 521.
‡ Comptes Rendus, xxx, p. 437.
§ Pogg. Annalen, xiv, p. 281.
‖ Astr. Journ., i, p. 105.

experiments between Washington and St. Louis ought to furnish a reply.

In the electro-magnetic telegraph offices, using Morse's patent, signals are communicated by the magnetization of a piece of soft iron, in the form of a horse-shoe magnet, and placed within a helix of wire. When the current flows, the iron becomes magnetic, and attracts an armature placed before it and connected with a graving tool. An endless fillet of paper is kept moving beneath the graver, by means of clock-work, so that the fillet is unmarked when no current exists in the wire, but is grooved by the action of the tool while the circuit is closed.

Fig. 1, (see Plate,) represents the recording apparatus and its adjustments. M is the magnet, A the armature, which is held back by the spiral spring S, while the current is not flowing, but is attracted as soon as the circulation of the current through the helix of wire has rendered M magnetic. The tension of the spring is regulated by a key. H is the reel for the paper fillet which receives the record; N a guide for directing and compressing the paper upon the roller R^1. The roller R^2 receives motion from the wheelwork W, and communicates it to the paper fillet F. While the armature is attracted, the indentor at the end of lever L presses upon the fillet, marking a groove whose length (the motion being equable) is proportionate to the duration of the electro-magnetism in M. The armature is never allowed to touch the magnet, but the proximity of its approach is limited by the stop I. This and the stop O which limits the outward motion, are capable of adjustment by screws. The distance traversed by the armature in passing from the outer to the inner stop is technically called the *pass*.

As the wire may be coiled into any number of helixes in the course of a circuit, there is no practical limit to the number of intermediate stations, each of which may receive all the signals quite as well as the terminal station. But since the intensity of the current decreases rapidly, as the distance from the battery increases, in consequence of the imperfect insulation of the wires, Morse's ingenious application of a local circuit is used, that these signals may be distinctly registered.

Fig. 2 represents a station on the main line. The signification of the letters is the same as in fig. 1, the key K regulating the spring. The armature-beam C is connected with one electrode of the local battery, the other being connected with the metallic inner stop I. An attraction of the armature closes the local circuit, on which is the recording apparatus, and thus a very weak current may suffice to close the circuit of the local battery, which may be regulated to any degree of intensity required.

Let us now suppose that at one extremity of a long circuit the pendulum of a clock is made to interrupt the current for a mo-

ment at each oscillation, the circuit being restored immediately afterwards as before. We shall have on the registers of the several stations a series of lines alternating with pauses or blank spaces,—*dots*, as they are called, in the technical phraseology of the telegraph.

If the fillets were moved forward with a uniform velocity by the machinery of the registering apparatus, and no changes occurred in the intensity of the current in the wire, each of the lines upon any one fillet would be of the same length,—as also would each of the pauses. And if the velocity given to the fillets at the several stations were the same, the lines representing seconds would be of one length on all the registers. This last we cannot expect, nor is it in any manner necessary, for it is an easy matter to reduce all the registers to a uniform scale. But that the motion of each single fillet be uniform is very desirable. To obtain a near approximation to such uniformity requires machinery far more delicate and more carefully constructed than that which is in use in the telegraph offices, and with which the experiments of the Coast Survey have been made. Such apparatus has been devised and is constructing by Mr. Boyden of Boston, and by Mr. Bond of the Cambridge Observatory. It forms also an essential part of the apparatus of Prof. Mitchel. Yet, as we are in fact dependent on the rate of the driving machinery of the registering apparatus only for a single second in each case, the error from this source is reduced to that arising from the alteration of velocity between the beginning and end of the same second. This is very small, except in extraordinary cases, and we may assume that all errors of this kind eliminate themselves when we use the mean of a number of cases, instead of isolated observations.

At each station on the line of telegraph, during the experiments for velocity, a contrivance is introduced into the wire circuit, of such a kind, that the circuit may be broken by pressing upon a key, which is restored by a spring to its original position as soon as the pressure is removed. One of these "break-circuit" keys is represented at G (fig. 1). It is thus in the power of the operator at any station to break the circuit whenever he chooses, and in this way to communicate at once with all other stations on the line.

After a galvanic battery and the circuit-breaking clock have been connected with the line, we have at each station, a clock scale, that is, a series of lines, separated by short pauses, each pause corresponding to the beginning of a second, whose duration is denoted by the length of the grooved line. In the clock of this kind at Washington, that pause is omitted which corresponds to the beginning of each minute, and this enables us to identify on a fillet from any station, the clock-pause made at a

given second. But whatever the velocity with which the clock-pause is transmitted,—or, in other words, however great an interval may elapse after the pendulum has broken the circuit before the pause is recorded on the register-fillet of a distant station,—we have as yet no means of detecting it; for in comparing the registers made at different places, this interval will (other things being equal) be the same for all the pauses, and therefore remain undiscovered.

Let us, however, imagine that while the clock is graduating its scale on all the registers as before, an arbitrary signal is given by breaking the circuit at some distant station. The comparison of the several registers will thus enable us to register the interval which elapses between the giving and the receiving of a signal. To fix our ideas, suppose the clock to be at Washington, the arbitrary signal to be made at Cambridge, and the time requisite for the transmission of a signal between the two cities to be the thirtieth of a second. Then the clock-pause will be registered at Cambridge $\frac{1}{30}$th of a second after it took place and was recorded at Washington, and the arbitrary signal-pause will be recorded at Cambridge as soon as it is made, or $\frac{1}{30}$th of a second *before* it reaches Washington. We shall thus have the interval between the signal-pause and the preceding clock-pause longer at Washington than at Cambridge, and the excess on the Washington register will measure twice the time consumed in the transmission of the signals between the two stations.

In order to avoid accidental errors, the mean of many measurements may be used,—and half the mean excess of the interval between a clock-pause and the next succeeding signal-pause gives us the time occupied for the transmission of a signal.

Such is the general method:—let us consider the possible sources of error and their probable influence. Every clock-pause and every signal-pause amounts in reality to a combination of two signals, distinct from one another, and subject to different general laws. The one consists of the electrotome, or breaking of the circuit: the other is the restoration of the circuit, or *electropaa*.—to use Mr. Walker's word.* We can consider the intervals between the signals as being the same as the intervals between the electrotomes, or beginnings of the pauses,—between the *electropaas*, or beginnings of the lines,—or as being more properly measured from the middle of one pause to the middle of the next. Mr. Walker has used the latter, the mean of

* Astr. Journ., i, p. 51.

the electrotome and electropœa readings.* For my own part, I prefer to use the electrotomes alone.

The only signal that can be made in a closed circuit is of course an electrotome. We break the circuit by tapping on the key. As soon as the finger is removed, the circuit is closed again by a spring, and an electropœa signal thus made. Do these two signals travel with the same velocity? If they do not, the clock-pauses must increase or diminish in length, as they are successively recorded at more remote stations. They must become elongated if the electrotome signal travel the faster, and contracted if the contrary. This question is an important one, but its discussion may be postponed for a while, as the length of the recorded pause is dependent on many other circumstances, and especially on the adjustments of the registering apparatus, which are not only very different at different stations, but appear to have been continually changed at the same station during the evening by the telegraph operators in charge of the registers. As far as I feel warranted in forming an opinion, I incline to the belief that these two kinds of signals traverse the circuit with equal speed,—or, to express the same idea in a different form, that induction of the electrical state in the successive molecules of the conducting medium, requires neither more nor less time than that required for a molecule to be restored to a condition of entire electrical equilibrium. The better to fix one's ideas in thinking on the subject, some hypothesis is desirable, which shall be capable of explaining all the phenomena; and I have accustomed myself to consider the propagation of electric polarity through a medium, as taking place† by the inductive force exerted upon each successive molecule‡ by the adjacent one.

If we consider the telegraph-wires as composed of a series of contiguous elements, an electrotome taking place at any point puts an end to the state of electrical tension in the nearest element on each side. The electrical equilibrium being restored in these elements, no force exists§ to continue the disturbance in the succeeding ones, and so on. An analogy to the propagation of an electropœa, or electric perturbation, may be drawn from the known laws of magnetism. If we have a curved rod of soft iron forming a little less than an entire circumference, and fill the gap with a bit of magnetic iron, the whole circle becomes magnetic. Although the period required for the transmission of this force is so short as to defy all attempts to measure it, there can be no doubt that a finite time intervenes between the introduction of the magnet and the magnetization of the most remote part of the

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* Proc. Am. Phil. Soc., v, p. 76. Astr. Nachr., xxix, p. 56.
† Faraday, Researches, i, § 1677. ‡ Ibid, § 1700.
§ Ibid, i, §§ 1671, 1686.

ring. When it is necessary to conceive some actual mode of transmission of signals, I am accustomed to represent it to myself in this way. The experiments of Wheatstone show that the electric spark took place at the same moment at points equidistant from the battery on the two sides, and latest at the point midway between the poles,—which is in perfect conformity with the hypothesis offered.* For the present, then, I may assume that electrotome and electropœa signals are transmitted with equal velocity; and, in a circuit composed of but one medium, in both directions.†

The circuit being suddenly closed, the electric disturbance is propagated through the telegraph-wire with a certain speed, and on reaching a registering station traverses the helix, imparting magnetic force to the encircled horseshoe of soft iron. The armature traverses the pass and closes the local circuit. The same phenomena are repeated in the local circuit and the graver attached to the armature-lever makes its mark upon the paper. All these processes require time, and the absolute interval, elapsed between the electropœa signal and its record on the paper fillet, is thus very considerably larger than that due to the time of transmission of the signal along the wire. The difference consists—

1st, of the *induction-time*, or time which elapses after the current is established in the helix, before sufficient magnetic power has been induced in the iron to overcome the tension of the spiral spring, and move the armature.

2d, of the *pass-time*, or time required by the armature for traversing the pass, and closing the local circuit.

3d, of the time of transmission of the electropœa in the *local* circuit.

4th, of the induction-time for the local-circuit magnet.

And 5th, of the pass-time in the same.

If the adjustments of the local circuit are good and are not changed during the experiment, and if the action of the local battery is constant, the last three quantities remain the same for all electropœa signals during the experiment, and exert no influence except in lengthening all the registered pauses by a very small quantity. This has usually been the case, and simplifies the problem very considerably, leaving us‡ only three unknown

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* A very strong analogy to a galvanic circuit is afforded by the charge and discharge of an electrical battery 'by cascade.' The first jar being connected with the prime conductor of an electrical machine,—a series of jars, where the interior of each successive one is connected with the insulated outer coating of the preceding, furnishes an imitation of a broken circuit connected with a battery. A connection made between the exterior of the last jar in the series and the interior of the first, either through a discharging rod or through the ground, corresponds to an electropœa or *make-circuit*. The difference between the charge of the first and of the last jar represents the resistance to conduction.

† Faraday, Researches, i, §§ 516, 1630.

‡ Walker, Astr. Journ., i, p. 52.

quantities to deal with,—the time of transmission and the induction and pass-times of the main circuit.

The record of the electrotome signal is not so much exposed to accidental disturbance. The moment that the current ceases in the helix, the enclosed iron begins to lose its magnetic condition, and as soon as it has parted with its magnetism sufficiently to allow the tension of the spiral spring to draw off the armature, the local circuit is broken. The outward pass-time has no influence upon the register. The only quantity to be considered is the time elapsing between the cessation of the current in the helix and the loss of magnetism in the iron. This interval is the converse of the induction-time, and might therefore be denominated the *eduction*-time.

The same that has been remarked of the corrections in the case of an electropœa holds true with regard to the propagation of an electrotome through the local circuit, and the eduction-time in its electro-magnet. The local-circuit adjustments being well made and continuing unchanged, and the intensity of the battery remaining constant,—the error from these sources is the same for all electrotomes and electropœas.

The chief source of error lies, then, as will be observed, in the pass-time of the armature of the receiving magnet, and may be totally avoided by using the electrotome signals only,—as it exercises no influence whatever upon these. It is for this reason that I have preferred to use the electrotome readings only, in preference to a mean between them and the electropœas. The pass-time is a very considerable quantity when compared with the small numbers with which we have to deal in these investigations.

The adjustment of the pass to the most convenient value is made by the operator, by means of the screws at I and O (figs. 1 and 2.) The force with which the armature is attracted may be considered as varying nearly in the inverse ratio of the distances,* except when in very close proximity to the magnet. The distance within which it may be allowed to approach the poles of the magnet is limited by the condition that the tension of the spiral spring must be strong enough to withdraw it as soon as possible after the circuit is broken, and yet not so strong as to delay its starting to return, when the circuit is closed again. The pass is then made as short as is practicable, allowing sufficient play to the armature for all the lines and pauses made on the fillet by the graver to be distinct and sharply defined. The following considerations have guided me in making an estimate as to the pass-time in the experiments under discussion.

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* Channing, Davis's Manual of Magnetism, pp. 150–155.

If we assume the intensity of the attraction exerted by the magnet on the armature to be equal to gravity at the earth's surface,—the following numbers give the pass-time for different lengths of the pass.

Length of Pass. Millimeters.	Time. Seconds.	Length of Pass. Millimeters.	Time. Seconds.
2·50	0·0226	1·25	·0160
2·25	·0214	1·00	·0143
2·00	·0202	0·75	·0124
1·75	·0189	0·50	·0105
1·50	·0175	0·25	0·0086

As far as I can judge, the usual pass in the main-circuit *receiving magnet* is between $1^{m\cdot m}75$ and $0^{m\cdot m}50$, which would on our present assumption, give the pass-time $0^{\cdot s}019$ and $0^{\cdot s}010$. An attractive force four times that of gravity would give the half of these numbers. But this mode of viewing the subject is a very rough one, for as the attraction varies with the distance, the initial force, (which exercises the greatest influence upon the time of passage.) would be much less when the length of pass is greater,—and the tension of the back-spring also operates to increase the pass-time very considerably. I incline to the belief that the average pass-time in the experiments of Feb. 4, was about $0^{\cdot s}03$. Mr. Walker, on the contrary, estimates it at $\frac{1}{15}$th of a second—more than twice as much. Had we any means of measuring the absolute duration of the interruption of the circuit by Mr. Saxton's clock, it would be of great service in aiding us to deduce the pass-time in many cases. In all conclusions drawn from the telegraph fillets alone, the pass-time and the induction-time are inseparably combined. Denoting the several intervals by their initials, we have for the length of the *recorded* clock-pause, which we will indicate by a *capital* letter, $C = c - e + i + p$.

As a first hypothesis, we may assume what appears not improbable from other considerations, that e and i are equal. Then subtracting the length of the interval during which the circuit was actually broken by the clock, the remainder would be the *pass-time*. For this purpose I solicited you to request Mr. Saxton to form some estimate, if possible, of the interval between the breaking and closing of the circuit, at each clock-pause. Mr. Saxton expressed himself unable to do this, which is much to be regretted. It had appeared to me that careful observations of the angle with the vertical, made by the pendulum at the time of striking the tilt-hammer, might justify some precision in forming an estimate. The pass-time, thus deduced, would in its turn enable us to examine into the propriety of our hypothesis regarding the equality of the *induction* and *eduction*-times. This is supported at present only by the result, in which I feel some con-

fidence—that the velocity of the electrotome and electropœa signals is the same. The latter is, however, inversely proportional to the sum of all the induction-times of the molecules on the line of wire,—the former to the sum of their eduction-times. If these are equal for the wire, the inference is natural that they are equal for the iron enclosed in the helix, if this be as soft as the iron of the wire.

Such speculations are indeed loose, and would not be warranted, were data within our reach for an accurate investigation of the question. But, as the problem now presents itself to us, everything appears interesting and worthy of consideration, which affords opportunity even for a presumption.

In the apparatus used by my friend Prof. Mitchel, he considers* that he is able actually to measure the length of the armature time, which is the sum of the induction and pass-times. The method which he uses is, however, incapable of being applied to the record made with Morse's instrument.

In an earlier part of my remarks, I deferred the discussion of the question whether the electrotomes and electropœas traveled with the same velocity, and yet have just now expressed the opinion that they did. The opinion was formed as follows:

We have the length of the recorded clock-pause, $C=c-e+i+p$, and of the recorded signal-pause, $S=s-e+i+p$.

If we take the difference of these, the three unknown quantities disappear, and we have $C-S=c-s$, the difference of the real duration of the pauses, equal the difference of their recorded duration. The only assumption here made is that the induction, eduction and pass-times are the same for both pauses,—an assumption quite warrantable if we compare each signal-pause with the clock-pause nearest it. They will then rarely be more than a quarter of a second distant from one another, and the values of the corrections are not likely to change appreciably within so short an interval. I have formed a table of the differences in the length of the same signal and clock-dots, for six different telegraph-stations on the line between Washington and St. Louis, and, from the discussion of more than a hundred different signals, find that the mean of these differences is almost identical for all the stations.

The intensity of the current even at the same place is quite unequal, owing to various influences, among which are thermometric and hygrometric changes in the atmosphere, which affect the insulation and the conduction; want of constancy in the batteries whose activity varies very much with variations of temperature; want of homogeneity in the substance of the plates; the continual formation† and flaking off of coatings of oxyd, and

* Astr. Journ., i, p. 16.

† Faraday, Researches, i, § 1144.

many other circumstances. We have already seen that the pass-time varies with the intensity of the electro-magnetism in the iron and consequently* with the intensity of the current,—and can therefore infer that the different clock pauses would not appear of the same length even on the same registers. That they do not, may be inferred from the following table, which gives the mean value of clock-pauses at each station for each one of five successive minutes.

MEAN LENGTH OF CLOCK-PAUSE.						
	S. S.	W.	P.	C.	L.	St. L.
8h.47	0s·072	0·068	0·055	0·095	0·096	0·092
48	0·091	0·050	0·067	0·090	0·093	0·100
49	0·094	0·065	0·055	0·084	0·125	0·110
50	0·103	0·071	0·059	0·081	0·103	0·118
51	0·100	0·078	0·055	0·081	0·093	0·102
Mean.	0·091	0·067	0·058	0·087	0·104	0·109

It will here be observed that the variations follow no general law whatever, the length of the pause decreasing at one station while it increases at another, and being in no way proportionate to the distance from the clock station, nor, so far as I can judge, to the strength† of the local batteries.

The pass of the Pittsburg register was too small,—so small as to render the register very indistinct and difficult to read, and it will be observed that the clock-pauses are the shortest on the Pittsburg register. The record upon the Cincinnati fillet was the most distinct of all, owing in part, however, to the finer quality of the paper. Clock pauses occur of every length. from 0s·04 to 0s·16. The average length is not far from 0s·086. I believe that the greater part of the irregularities are due to causes much less occult than those we have been considering, and chiefly to irregularities and imperfections in the mechanical part of the registering apparatus.

Bain's galvano-chemical telegraph affords an opportunity of trying the experiment under circumstances totally independent of the pass-time, which has proved so troublesome in the experiments made with Morse's apparatus. The paper on which the record of Bain's telegraph is made, is colored with a solution of ferrocyanate of potash. It rests upon a revolving metallic disc connected with one pole of the battery, while a needle or finely pointed wire connected with the other pole, trails on the upper surface. When the circuit is closed, the current passes between the needle and the metallic disc, coloring the paper in its passage by the partial decomposition of the ferrocyanate. Walker has

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* Fechner, Schw. n. Jahrb., ix, pp. 274, 316. Lenz and Jacobi, Pogg. Annalen, xlvii. 233. Bull. de l'Acad. de Pétersburg, vol. iv.

† Pouillet, Comptes Rendus, iv, p. 272.

made a series of experiments with this telegraph between Boston and New York.* But although the pass-time is here avoided, other sources of error are introduced. The times† of delay and of persistence in the chemical action take the place of the induction and the eduction-times in the electro-magnet, and a new and serious difficulty presents itself in the spreading of the lines which have undergone chemical action.

The character of the electro-chemical telegraph allows no local circuit, in the technical sense of this term, and indeed it is unnecessary, for a current capable of closing a local circuit would suffice to act with energy on the very sensitive salt with which the paper is saturated.

But in the experiment for velocity, it is indispensable that a record be kept at the two terminal stations, at least; and the closing of the circuit, in order to record at one station, necessarily diverts the current from the other. With a powerful battery a record may be successfully kept at stations no farther distant than New York and Boston; but if we use a line as long as that between New York and Buffalo, a battery so powerful as to burn a hole through the paper at one terminus, cannot record signals at the other, when the circuit of the signal-station is closed.

Mr. Bain has ingeniously remedied this difficulty by using a short circuit at the signal-station, which is closed by the same key that closes the main circuit. Yet even this introduces still a new source of uncertainty. A curious result which Mr. Walker has deduced‡ from his experiments consists in the fact that the discolored lines, which measure the duration of the current, are longer at the station where the signals are given, than at the other extremity of the line. An inference might be drawn from this, opposed to that which I have drawn from the St. Louis registers, concerning the equality of velocity for the electrotomes and electropœas; but it appears to me more probable that the circumstance is due either to the difference of circuit or to the superior intensity of the current, and consequently, of its chemical action at the signal-station. The question remains open for discussion.

The experiments of Fizeau and Gounelle, in France, described in the *Comptes Rendus* for April last, were made on an entirely different principle, and conducted them to a series of inferences which they give in detail. The published description§ of their method is very obscure, and the data on which their inferences are founded are not fully given. Their method appears to be in some degree, analogous to the very elegant experiment‖

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* Ast. Journ., i, p. 105.
† Proc. Am. Assoc., 1849, p. 189. Ast. Journ., i, p. 108.
‡ Ast. Journ., i, p. 106.
§ Comptes Rendus, xxx, p. 439.
‖ Comptes Rendus, xxix, pp. 90, 132.

by which Mr. Fizeau had previously measured the velocity of light between Paris and Montmartre. A wheel, whose circumference consisted of 36 divisions, alternately of wood and platinum, revolved in contact with the edges of insulated plates of platinum, each pair of plates forming a distinct circuit-breaker. The driving machinery of the wheel was connected with an apparatus for measuring the velocity of rotation; and the effect of different velocities and different circuits was observed upon the galvanometer.*

The velocity of the current, which they deduced from these experiments, was, as I have already mentioned, 63,200 miles per second in iron wire 4 millimeters in diameter, and 110,000 in copper wire, $2\frac{1}{2}$ millimeters in thickness.

They inferred, moreover,

That the two electricities were propagated with the same velocity.†

That the tension of the electricity has no influence on the velocity.

That the velocity does not vary with the section of the conducting material, but only with its nature, and then not in the ratio of the conductive power.

That the discontinuous currents "experience a diffusion, in consequence of which they occupy a space greater at the point of arrival than at the point of departure."

This latter result is in direct opposition to the experiments of Walker with the chemical telegraph, by which, using a method of determination indefinitely less complicated he found the length of duration of the electric currents to be less at the more remote station. According to Fizeau,‡ the electropœa is propagated more rapidly than the electrotome;—according to Walker.§ less rapidly. Fizeau used a circuit 374 miles in length, and Walker one of 250 miles of wire, whose two extremities communicated with the ground about 190 miles apart.

The Coast Survey experiments of Feb. 4, on the line between Washington and St. Louis, 1045 miles distant by the wires, and 742 in a geodetic line, lead me to suppose, as already stated, that the velocity of the two signals is the same, and (other things being equal) the pauses would be of equal length, as recorded at all the stations on the circuit. I am inclined to attribute Walker's results to the more intense chemical action of the current on the prepared paper at the signal stations,—and while entertaining the most profound admiration for the remarkable ingenuity and care shown by Fizeau, I cannot consider his method as capable of giving results worthy of implicit reliance.

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* Becquerel, Traité, v. p. 275.
‡ Comptes Rendus, xxx, p. 440.
† Faraday, Res., i, §1333.
§ Ast. Journ., i, p. 106.

Walker's conclusions respecting the velocity are by no means inconsistent with Wheatstone's experiment; for the tension of the electricity and the conducting power and size of the wire differ so much in the two cases as to prohibit any comparison. Fizeau's, on the contrary, stand in the directest opposition to it, for he finds that neither the tension of the transmitted electricity, the intensity of the current, nor the size of the conductor, exerts any influence on the velocity; and at the same time makes the velocity through his copper wire to be 110,000 miles a second, while Wheatstone found 288,000 to be the minimum limit of the velocity through the copper wire which he used.

(To be continued.)

ART. VII.—*Reply to Mr. De la Rue's remarks on the Navicula Spencerii contained in the American Journal of Science, Vol. IX, p. 23; with a notice of two new test-objects;* by J. W. BAILEY.

In consequence of absence from home and long continued illness, I have been compelled to delay my reply to the remarks by Mr. De la Rue upon the subject of the Navicula Spencerii. I trust however that it is not too late for a few words in answer. Mr. De la Rue now admits that the American observers were right in attributing the appearances seen on these shells to rows of prominences, and not to perforations or depressions as stated in Mr. Queckett's Treatise, (p. 440,) and as the larger figure on Plate 9 of that work represents them. As we agree with regard to the structure of these objects, the only remaining points of difference between us are the measurements of the distance between the rows, and the difficulty of the species as a test-object. With regard to the accuracy of my measurements it was impossible for me to judge, as Mr. De la Rue's were not made on the "identical specimens" mounted by me, but on others mounted in London and which might have been large and easy individuals. Fortunately however, the means of comparing our measurements of the same object has been kindly furnished me by Mr. De la Rue himself to whom I am indebted for one of those wonders of art, the Nobert Test plates. This was accompanied by a table giving the measurements of each of the fifteen bands of lines upon the plate, the finest set of lines being 56306 to the English inch. By measuring the coarser bands of this test plate, by the ordinary method, the same as used by Mr. De la Rue, I find that my measurements constantly differ from his, and always in the same direction and amount. As the measurements of the coarser lines is too easy for any error in manipulation, I can only conclude that our scales of comparison,

i. e., our micrometers must differ. My own is an English one divided to $\frac{1}{10000}$ths of an inch. Mr. De la Rue states that his is divided to $\frac{1}{50000}$ths of an inch. Which of the two is the most accurate I cannot now determine, and must leave it to future observation, I will remark however that Mr. Spencer of Canestota in some measurements which he has recently made, obtained results intermediate between those obtained by Mr. De la Rue and myself, making the distance between the transverse rows about $\frac{1}{30000}$ of an inch.

In his remarks, Mr. De la Rue emphatically states that at the time of its arrival in London, the markings on the N. Spencerii shown as lines were not a difficult test for the object-glasses of the London observers.

I leave it for others to reconcile this statement with the quotation which I gave from a letter from a London correspondent, which I will now requote, as follows:—

"The evening I received your package there happened to be a small gathering of our microscopic friends. Your slide with the Navicula Spencerii underwent a long examination. We however could make nothing of it. * * * We had some of the best glasses of Smith, Ross and Powell in our examination, and I am bound to state that at present the result is most unsatisfactory."

It appears from the above that it was not Mr. Marshall's glass alone which in the earlier trials of this test in London failed to resolve it. The fact was that all observers found it a difficult object until they became aware of the great obliquity of light required, and most observers admitted it to be a far more difficult test than any at that time known. Mr. De la Rue appears to be the only one who found no difficulty in his first attempts to see this as a lined object, probably owing to the fact that the difficulties of the problem had been previously solved by his friend, Mr. Marshall, so that in their united observations the proper illumination was at once employed. Mr. De la Rue himself gives evidence that the test is one of some value, for it seems that with all his skill it was only "after working about an hour that the dry specimen was resolved most satisfactorily" as a dotted object.

But I will not dwell upon the subject of the early experience of observers at home and abroad with regard to the test, as it has for some time given place to still more difficult species of lined Naviculæ. I have only wished to relieve myself from the imputation of having "unwillingly overrated" its difficulty. When I claimed that it was worthy of a high place in the list of tests, I was guided by the authority of the best English observers who both in print and in private letters referred to the Navicula Hippocampus as one of the most delicate of lined objects. Finding that the N. Spencerii was far more delicate, and that many glasses failed to resolve it which appeared to perform well upon

the N. Hippocampus, I felt authorized to call the attention of microscopists to it as an object more difficult than any *then* known, by publication, to the scientific world. That rank I still claim for it, but at the same time admit that with proper illumination it may be resolved with ease and certainty by object-glasses of only moderate power made by the English artists, Ross, Powell, Smith, or by our own countryman, Spencer.

To Mr. Spencer I am indebted for the knowledge of two test-objects of far greater difficulty than the N. Spencerii. The first is a species of Grammatophora. The larger species of this genus may be easily made to show sets of prominences producing the appearance of transverse, longitudinal, and even diagonal lines, but the species to which I have applied the name of G. subtilissima has markings of such exceeding tenuity, that I failed to resolve it with one of Spencer's object-glasses, "a sixteenth," made for me about two years ago, although the same glass would readily resolve the N. Spencerii. A new object-glass of admirable workmanship made for me by Mr. Spencer resolves this new test with great ease, as does also a new object-glass ("a twelfth" I believe) made by Ross of London and recently imported by Mr. Cole of Salem. The *G. subtilissima* occurs along our whole coast from Massachusetts to Florida. In form it resembles the G. marina of authors, but is more delicately marked than my European specimens of that species. The specimens with the finest markings I found growing upon the Polysiphonia Olneyii of Harvey, near Providence, R. I.

Another test which is a little more difficult than the last is a species of Navicula sent by Prof. Amici to Mr. Spencer as a test-object which he would probably find sufficiently difficult even when mounted dry. This test Mr. Spencer proposes to call Navicula Amicii, in honor of the distinguished microscopist from whom it was received. It is a small lanceolate freshwater Navicula with exceedingly minute markings which on some specimens appear to me more difficult than even the Providence specimens of the Grammatophora. They however are not beyond the reach of Spencer's new object-glasses which will satisfacterily resolve them even when mounted in balsam. I think that when Mr. De la Rue sees these objects, his doubts "whether the physical properties of light do not put a natural limit to our resolving lines so close as the $\frac{1}{120000}$th and $\frac{1}{200000}$th of an inch" will be removed.

Note.—Since the above was in type, I have been informed by Mr Spencer, that he considers many of the specimens from Providence as more difficult than any of the specimens of Amici's test. The Grammatophora from Greenport, Long Island, is decidedly easier.

Art. VIII.—*Miscellaneous Notices;* by J. W. Bailey.

1. *Fossil Infusoria of the Southern Ricefields.*—The earth of the rice fields in Carolina and Georgia is rich in fossil, (marine or estuary,) siliceous Diatomaceæ. They are particularly abundant in the earth freshly excavated in forming the canals and ditches, and hundreds of little shells may be seen with even a common pocket lens, upon the freshly fractured surface of any dry lump of the mud. The species are such as now inhabit the shores and estuaries of the Atlantic states, and which extend much farther up the streams than where the *surface* water is fresh. Among the most common forms are Triceratium favus, Coscinodiscus subtilis, C. excentricus, Gallionella sulcata, Rhaphoneis Rhombus, Terpsinoë musica, Zygoceros Rhombus, &c. The localities examined by me were, on the Ashley river, near Middleton Place; on the Savannah river at Dr. Daniell's plantation, opposite Savannah, and at the deep excavations for ditches, &c., at Fort Jackson; on the Ogeechee at the plantations of R. J. Arnold, Esq., and of Judge Cheves; and on the Altamaha at Hopeton, the classic ground of southern natural history, near the residence of J. Hamilton Couper, Esq. A perfect agreement was found in the character of the fossils at all these localities.

2. *Localities of Terpsinoë musica*, Ehr.—This exquisite siliceous shell whose markings Ehrenberg aptly compares to a double row of musical notes, enclosed in a glass casket, was first discovered by Ehrenberg in deposits brought from Mexico: Kützing states that he has found it adhering to roots of Marchantia from South America, and Ehrenberg has recently stated* that it occurs abundantly in Texas, but adds however, that it has not yet been detected in the older states of the Union. I am happy to be able to state that it is a common and abundant form in our southern rivers. During the last winter I found it in a living state in the waters of the Ashley, Savannah, Ogeechee, and Altamaha: also in great abundance forming long chains on the roots of Pistia stratiotes in the St. Johns, Withlacoochee and Hillsborough rivers in Florida. I have also specimens of it from Jamaica, and a few portions of apparently the same thing, from Mindanao in the Phillipine Islands. It probably inhabits the rivers of all warm regions. It is abundant as a fossil form in the ricefields.

3. *Fossil Infusoria of Maryland.*—The infusorial beds of Virginia and Maryland, have been heretofore traced from Petersburgh, Virginia, to Herring Bay on the Chesapeake in Maryland, and here "the *trail*" was lost: I have had the good fortune to

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* Monatsbericht, &c., Berlin, Feb., 1849.

recover it again at Wye, on the eastern shore of Maryland, where the infusorial stratum reappears with all its usual characteristic species.

4. *Silicified Polythalamia in Florida.*—While passing from Pilatka to Tampa Bay, in Florida, I collected at "Piles's New Place," about forty miles west of Pilatka, large masses presenting all the mineralogical characters of flint. These occur in veins in masses of the white Orbitulite limestone which is common throughout this portion of Florida. Much of this flint is sufficiently translucent to be mounted in thin fragments coated with balsam for microscopic examination. By this means I detected in it numerous silicified specimens of Orbitulina, Nummulina, Rotalia, Textilaria, &c. The siliceous arrow heads found in great abundance in Florida, often present a similar character, and are doubtless from the same formations.

5. *Localities of Paludicella articulata*, Allman.—This beautiful Bryozoan polyp appears to be common in the Highlands of New York, I have found it in considerable abundance in all the ponds near West Point, and also in ditches leading from a swamp near the Crows Nest. It occurs attached to various submerged objects, such as growing plants, bits of wood or stone, fallen leaves, &c., over the surface of which it spreads in an irregular branching manner, sending up from each joint a beautiful animal flower, formed of tentacles covered with vibrating cilia. I have kept it by me for weeks and find it a charming object for microscopic study. A figure and description of it may be found in the London Physiological Journal, vol. i, p. 10.

6. *Circulation in Hydrocharis spongiosa.*—This plant grows in almost every wet place in the Southern states, where it is often known by the name of "Colts foot;" I recommend it to southern microscopists as a beautiful object for the study of the circulation. The hairs covering its aquatic roots are as transparent as glass, and afford an admirable display of the currents, and also of revolving cytoblasts.

ART. IX.—*On the time required to raise the Galvanic Current to its maximum in Coiled Conductors, and its importance in Electro-Mechanics;* by Prof. CHAS. G. PAGE, M.D., Washington, D. C.

M. POUILLET communicated to the French Academy in 1837, "that he had established that a circuit of many thousand metres in length, was traversed by the current in a space of time that did not amount to $\frac{1}{1000}$ of a second; and that in this very brief instant it was not simply a portion of the electricity that was

manifested in the circuit, but that the entire current passed with all its intensity." Prof. Henry, however, in his valuable paper on electro-dynamic induction, published in 1840, takes the more consistent ground as follows. He remarks that, "rapid as may be the development of the current, it cannot be supposed to assume *per saltum*, its maximum state of quantity; on the contrary, from the general law of continuity, we would infer that it passes through all the intermediate states of quantity, from that of no current, if the expression may be allowed, to one of full development; there are however, considerations of an experimental nature, which would lead us to the same conclusion, and also to the further inference that the decline of the current is not instantaneous." Prof. Henry also inferred that the "time of the subsidence of the current when the circuit is broken by means of a surface of mercury was very small, and did not exceed the ten thousandth part of a second." He also inferred that "when the circuit is broken by a cup of mercury, the rate of the diminution of the current within certain limits remains the same, however the intensity of the electricity or the length of the conductor may be varied."

I have lately made some remarkable experiments with large coils and powerful currents, which fully and most strikingly establish the "gradual rise and subsidence of the current." The results lead to conclusions differing from those of Henry only with respect to the importance of conduction in regard to the rise of the current. I am led to infer that resistance to conduction within ordinary limits in coiled conductors at least may be neglected in the rise of the current as well as its subsidence, and that the time of subsidence is the same as that of the rise of the current, and that both depend upon the force of the induced current. The induced current *ceteris paribus* depends upon the figure, size and construction of the coil, and therefore, the rise and subsidence of the current is governed as to its time, chiefly by the configuration and size of the coil.

The coils used in my experiments are of peculiar construction to be hereafter described, and each presented a circuit of 600 feet in length. Five of these were used in all, and thus gave a total length of 3000 feet. On connecting a powerful Grove's battery with one of these coils, it was evident at once that if the circuit were of short duration, the secondary spark was small, and if the circuit were prolonged by continuance of contact, the secondary spark was proportionally increased in volume and sound. It was not difficult by the aid of a metronome, to time the contact and to ascertain with some accuracy the time required to give the spark its full effect.

On connecting two, three, or more coils with the same battery, the result was much more striking, from the fact that the

maximum effect of the induced current, or the volume and noise of the spark were so much increased, although the time required appeared to be the same. It was only from the great contrast manifested between almost "*no current*," and a full development of a current which produced a secondary spark of nebular form, having an average diameter of three inches. I may remark here that the form of the spark depends entirely upon the manner of breaking the circuit. When the wires are separated slowly the spark is nebular in form, but when they are separated suddenly and carried to a considerable distance apart, the spark is linear or nearly so, and I have obtained it sometimes when a bar of soft iron was inclosed, from *six to eight inches* in length, and I have no doubt that by following out the novel suggestion of my friend, Mr. Lane, viz., to shoot away the connecting wires by a cannon ball, a spark of a foot or more in length, might be obtained. About twelve years ago I noticed in this Journal a nebular spark of nearly one inch in breadth from a powerful magneto-electric machine, and a linear spark of $\frac{3}{4}$th inch in length from the same machine, but do not remember that they excited any special attention at that time. Their very great magnitude in my present experiments, however, renders them objects of intense interest and beauty. When a soft iron bar is inclosed in the coils, the nebular spark is frequently spread out from five to six inches in breadth. But to return to the subject. Measuring the time of the rise and fall of the current by the metronome, it was found to be from $\frac{1}{6}$th to $\frac{1}{3}$th of a second; when the coils were used alone and when a soft iron bar was included, the time was from $\frac{1}{2}$ to $\frac{3}{4}$th of a second.* The presence of the iron bar increases the initial induced current, and thus delays the rise of the battery currents, and the terminal secondary is also increased and thus sustains or prolongs the duration of the battery current.

It is very interesting to close the circuit in the coil surrounding the iron bar, and watch the subsidence of the current in the coil after the battery current has been entirely removed from it. On opening the circuit by separating the ends of the coil, sparks may be seen at any time within half a second.

From these results it is seen that the time of rising and falling of the current is not only appreciable, but that its great duration makes it a very important element to be considered in the operation of electro-mechanical contrivances. Where magnets are to be charged and discharged, the time of the coil and the additional time of the magnet must be considered, and also the inductive effect due to motion. Where the magnet is to be always charged as in my electro-magnetic engine, the time of the coil and the inductive effect of motion are to be considered. By certain con-

* This view of the case I stated in this Journal in 1838.

trivances which will be described at some future time, I have been enabled to obviate mostly the principal difficulty, viz., the time of the coil, or rather to turn it to a practical account, and to this in part is due my recent great success in the application of this power. I have now an engine of nine to ten horse power, the details of which cannot be given here.

I notice that Mr. Hunt in a recent address before the Society of Arts, in London, describes the effect of secondary currents and also the effect of motion in diminishing the power of electro-magnetic engines, and claims that the subject was then for the first time specifically brought forward. In 1838 I prepared a special paper upon this subject, which was published in Silliman's Journal at that time, in which I fully set forth and anticipated all these difficulties, and also shewed by an instrument termed the Magneto-Electric Multiplier, how the secondary current might be used to increase or diminish the motion of a revolving magnet.

The method of determining the time for the rise of the current in my coils by means of the metronome, and the size of the sparks is not to be relied upon for entire accuracy, and I have in contemplation an instrument by which it can be done more perfectly.

Note.—In a recent letter from Dr. Page, he mentions the following experiment with his powerful magnet.—Eds.

"I have just completed a grand experiment with a huge iron bar and helix, with the following results. *The bar weighing 532 pounds placed within the helix, is made to start up in the coil and vibrate in the air without visible support.* It requires a force of 508 pounds additional to its own weight to pull it out of the helix, so that it is equivalent to lifting a bar in the helix, of 1040 pounds in weight. After this it would seem quite easy to sustain masses of iron weighing many tons. The full time required to charge this magnet and raise the galvanic current to its maximum is two seconds. Nine-tenths of the charge is attained in one second."

Art. X.—*A new figure in Mica and other Phenomena of Polarized Light;* by Prof. Chas. G. Page, M. D., Washington, D. C.

In order to exhibit well the system of rings in mica, we must select the clearest specimens of uniform appearance and density, and the piece should be at least $\frac{1}{20}$th of an inch thick. If the mica be very clear it may be somewhat thicker to advantage. The inclination of the *resultant axes* is so great in mica, that but one of the systems can be seen at once: but by crossing two thick pieces I have found that the two will so compensate as to exhibit in a most beautiful manner the two systems of each piece,

and in addition a charming system of hyperbolas. The pieces, each about $\frac{1}{16}$th of an inch thick, are cemented into frames revolving one within the other, and allowing the mica plates to come very near together without touching. In viewing this figure by polarized light, the Nicols prism is held perpendicular to the mica plates, and not inclined as in viewing a single thickness of mica. Fig. 1 is a representation of this interesting composite system. The colors are brilliant, and the negative figure is not less pleasing than the positive.

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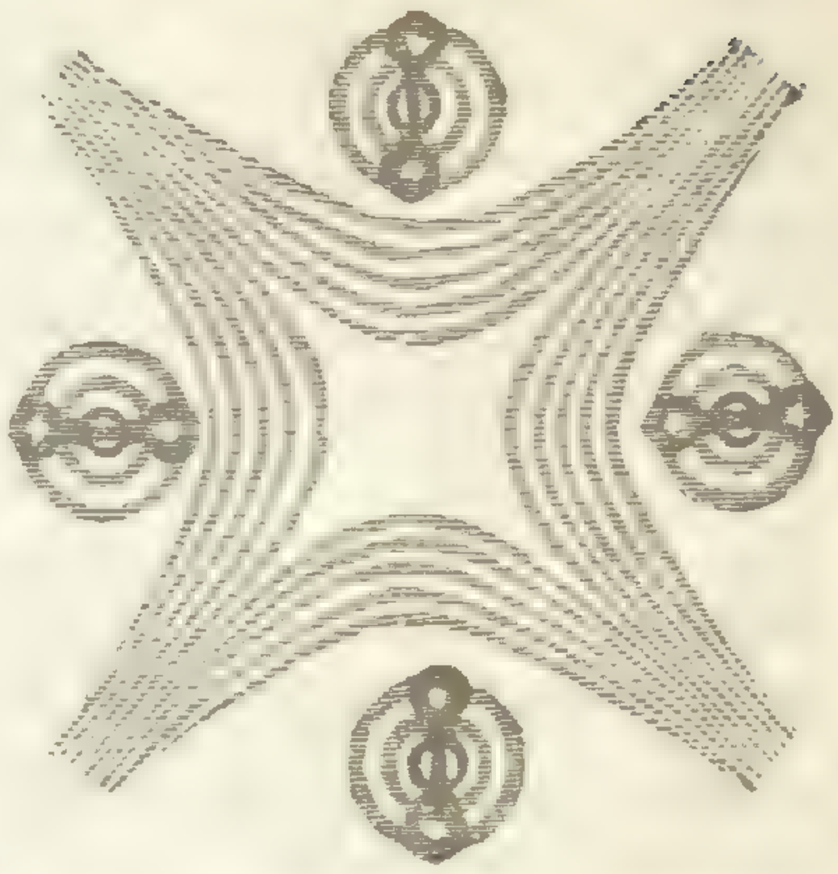

Polarization by Caoutchouc and Gutta Percha.—Gutta percha when rolled into thin sheets or drawn into ropes comports itself like a fibrous substance, which is not the case with caoutchouc. A strip cut from a thin sheet of gutta percha may be stretched considerably in one direction, that is, in a line with the fibre, but any attempt to stretch it across this line, is followed at once by a rupture. It is not so with a sheet of caoutchouc, which will stretch equally well in all directions. On examination of thin sheets of these two substances—so far believed to be *isomerical*—a marked difference of texture is at once perceived. The caoutchouc gives little or no change of color, while the gutta percha exhibits a beautiful spectacle. It appears to be built up of prisms of every variety of hue, and as it were fused into each other. It resembles more nearly some specimens of ice which I have examined, than any thing else. The caoutchouc and gutta percha must be kept under considerable tension during the examination.

There is one mode however, in which I have produced some fine figures by means of caoutchouc. The caoutchouc is made into little balloons in the following manner. A very thin sheet is tied over the end of a tube of one half inch bore, and the caoutchouc blown out into a ball and firmly tied just beyond the end of the tube with a piece of silk. The form and size of these balloons are nearly as represented by fig. 2. They can with a little practice be very conveniently made by the mouth. The caoutchouc is drawn over the open mouth and by strong suction it is forced in filling the mouth, when the lips and teeth are compressed over the outer portions, so as to form a neck which is at once twisted up by the fingers and secured with a string. The caoutchouc thus

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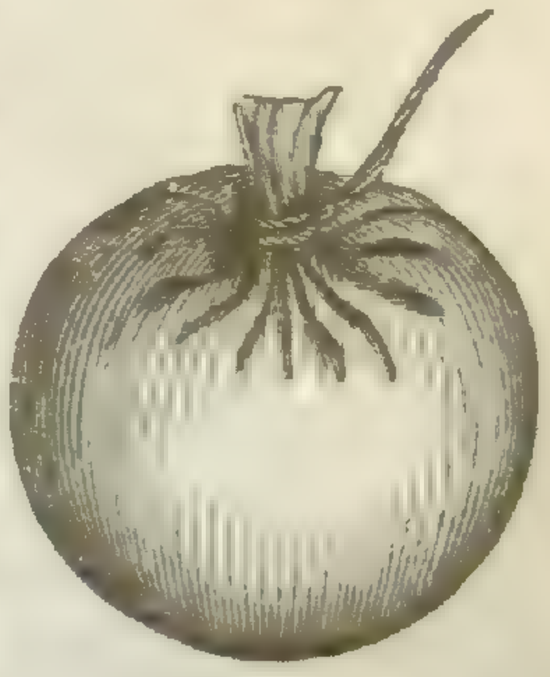

highly stretched becomes almost transparent, and when viewed by polarized light it gives when in this constrained condition a definite system of colors, not unlike the figures produced in a circular piece of tempered glass.

On a mode of preparing figures for exhibition upon screens by the apparatus of Soleil.—There are no exhibitions within the whole range of optics so fascinating as those with the apparatus of Soleil, in which the various figures, systems of rings and colors by polarized light from crystals, tempered glass and other substances, are thrown upon a large screen in a darkened room. Among the many objects accompanying polarizing apparatus received in this country from Europe, there are usually one or two tasteful diagrams representing a flower, gothic window of stained glass, or some pleasing device. These pieces are prepared at vast labor and expense, and are in reality mosaic work, of thin pieces of selenite cemented to glass by Canada balsam. The selenite is first split into thin laminæ, and each piece examined by polarized light to ascertain its color. The pieces are then assorted according to their thickness, and after being cut into shape according to the character of the diagram or form to be represented, are laid upon glass as before stated. But as each piece will give two distinct complementary colors in one revolution of the eye-piece, they must be carefully examined and cut in reference to their neutral and depolarizing axes in order to a proper disposition of the colors in the figure. From the foregoing it will be readily seen how delicate and difficult is the task to prepare even a small flower in this way. Added to this, the selenite is very fragile and difficult to work, and requires very skillful manipulation. Some of the more elaborate diagrams are very expensive, costing from £15 to £20. Dr. Brewster suggested a mode of making such figures upon selenite, by scratching out the surface, and afterwards polishing it; but this would be more difficult of execution than the mosaic work. It occurred to me that a good effect might be produced by engraving in a peculiar way upon mica, and my first trials about three years since were quite successful and encouraging. The *modus operandi* is as follows: A piece of very clear and uniform mica is selected, about $\frac{1}{30}$th of an inch thick, and this is examined by polarized light to ascertain its color. If the mica splits well we may have the ground-work of almost any color desired, by gradually removing very thin layers and repeating the examination each time. The mica is then laid and secured in place over a drawing or engraving of a bird, flower, butterfly, or any object fancy selects. The whole outline of the figure is then traced upon the mica with a sharp steel point, taking pains to use uniform pressure. The entire film of mica circumscribed by the tracer is then removed by lifting one edge

with a lancet point and stripping it off, and thus we have a new color for the whole figure differing from the ground-work, and we may now proceed to trace all the details, by cutting in to a greater or less depth and detaching the films by the lancet point, and having a polarizing mirror before us and a Nicols prism, we can in a few hours complete a work which will vie in splendor with many of the selenite specimens that occupy many weeks in construction. The pieces when finished are put into frames and are much improved, and protected by being placed between plates of glass with Canada balsam between them. Figs. 3, 4, and 5, are some of the pieces I have executed in this manner, and although not one of them occupied me more than five hours, yet they are truly splendid objects when magnified upon a screen. These illustrations will

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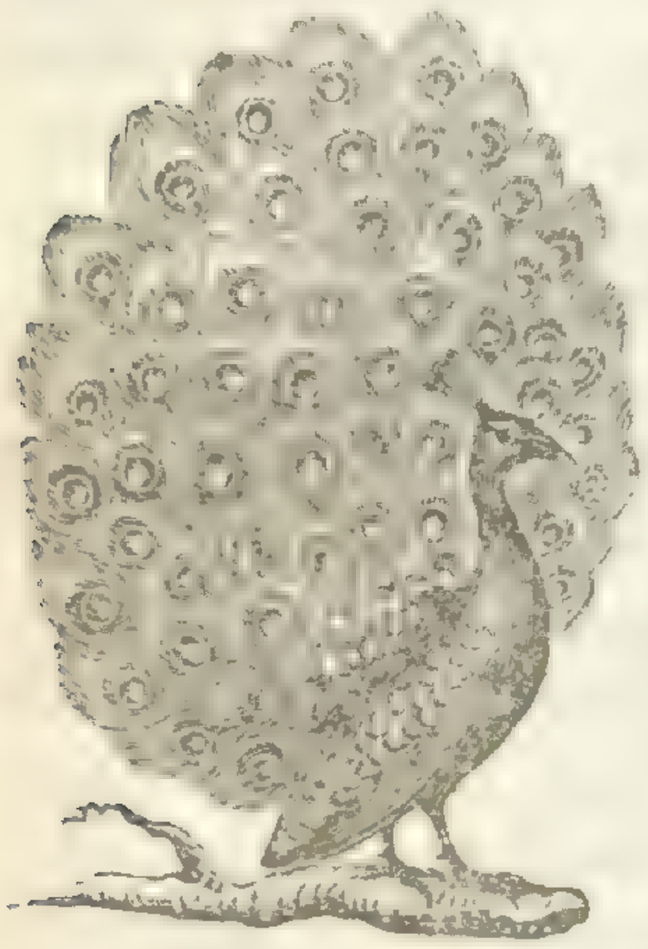

5.

serve as models for any one to work upon, and although seemingly difficult, yet even an unpracticed hand cannot fail to bring out something gratifying. In the figures of the peacock and chameleon, I took the liberty of coloring the trunk of the tree with the brush, which adds much to the picture.

Washington, November 12, 1850.

ART. XI.—*Descriptions of new species of Fungi collected by the U. S. Exploring Expedition under C. Wilkes, U. S. N., Commander*; by Rev. M. J. BERKELEY and Rev. M. A. CURTIS.

AGARICUS (Pleuropus) LAGOTIS, Berk. and Curt.;—pileo sessili elongato-conchiformi, antice latiori; strato superiore gelatinoso setoso-velutino; lamellis subconfertis.—Ad lignum. Oahu, Sandwich Islands.

Cap 1¼ in. long, sessile, narrowed behind, broad in front, the upper surface clothed with dense short soft bristles, at length naked in front. Gills moderately close, tawny when dry, edge entire. Spores white, round-oval.

Allied to *A. atropurpureus*, but differing in the coarse velvety coat which resembles that of *Exidia hispidula*, Berk. It also bears a strong resemblance to *Lentinus pelliculosus*, but the hairs are not fasciculate as in that species, nor are the gills toothed, not to mention the generic difference.

A. (Flammula) CRÆSUS, Berk. and Curt.;—aureus; pileo carnoso excentrico pilis innatis subtiliter squamoso; stipite brevi obeso; lamellis postice emarginatis confertis; sporis minoribus ellipticis.—Ad lignum (pineum?) Waha-rua Bay, New Zealand.

Cap 3 in. broad, sprinkled with obscure appressed pilose scales; stem 7 lines long, 4 thick, paler that the pileus, furfuraceo-tomentose; gills broad, strongly emarginate or sinuated behind, scarcely adnate, of a uniform golden yellow, not spotted.—Closely allied to *A. aureus*, but differing in its short excentric ringless stem and far smaller spores.

LENTINUS WILKESII, Berk. and Curt.;—tener; pileo profunde infundibuliformi subtiliter tomentoso lineato; stipite subæquali sursum furfuraceo deorsum nigro; lamellis confertissimis tenerrimis spiculiferis.—Ad lignum. Feejee Islands.

About 1 in. broad, white, finely streaked, margin slightly incurved; stem 1½ in. long, scarce 1 line thick, black below, pale and furfuraceous above; gills extremely delicate and close, the edge very finely notched.—Closely resembling *L. pergamenus*, Lev., but more infundibuliform and with much more crowded gills.

POLYPORUS BRUNNEOLUS, Berk., in Lond. Journ. Bot., III, 187;—var. opacus; pileo renato-flabelliformi antice lobato tenui crebri-zonato sulcato opaco subtiliter tomentoso postice hic illic fucato glabro, pallide brunneolo zonis obscurioribus; stipite brevissimo disciformi; hymenio albido; poris minutis punctiformibus, acie integra obtusa.—Ad corticem arboris.—Samoan Group.

There is but a single specimen of this in the collection, which agrees pretty well with one of the original specimens from the Philippine Isles.

P. LITURARIUS, Berk. and Curt. ;—carnosus tenuis ; pileo flabelliformi glabro lineolato ; stipite brevissimo cum pileo postice attenuato confluente ; poris minutis angulatis, dissepimentis tenuissimis denticulatis.—Ad lignum. Feejee Islands.

Cap 1⅓ in. broad, 1¼ long, slightly lobed, reddish brown, marked with fine radiating lines, slightly depressed behind where it is confluent with the extremely short though strictly defined stem ; edge slightly incurved ; hymenium probably white.—A very distinct species to which we cannot point out any near ally. *P. Drummondii* is perhaps the nearest. It also resembles *P. sector*, but has no raised lines and is quite smooth.

FAVOLUS PLATYPORUS, Berk. and Curt. ;—pileo reniformi sublobato rigidiusculo glabro e contextu supra dissepimenta contracto reticulato ; poris amplis oblongis subhexagonis, dissepimentis emarginatis rigidis, acie subintegra.—Feejee Islands.

Cap 2½ in. broad, 1½ long, depressed behind, reticulated by the contraction of the substance above the dissepiments, edge very thin and acute. Stem extremely short, disciform. Dissepiments scooped out in the middle, pores 2 lines or more long, 1 line broad, but varying much in size.—Nearly allied to *F. alutaceus*, Mont. and Berk., but differing in its larger pores and reticulated surface. The pores are more rigid than in any other species with which we are acquainted except an undescribed species from Canada, which has not however the reticulated pileus. *F. intestinalis*, Berk., has pores as large, but is totally different in other respects.

THELEPHORA LAMELLATA, Berk. and Curt. ;—tota ochracea ; pileo infundibuliformi lobato rugoso-lamellato subtiliter tomentoso ; stipite elongato velutino-tomentoso ; hymenio sulcato rugoso glabro. Feejee Islands.

Pileus 2 in. broad, 1¼ deep, lobed, subplicate, clothed with permanent appressed down, coarsely lamellate rugose. Stem equal, cylindrical, 1½ in. high, 2 lines thick, densely downy, almost velvety, solid. Hymenium rugose-plicate. The whole is of a beautiful ochre or tan color.

This species is rather larger than *T. caperata*, Berk. and Mont., is more strongly lamellate, has a very different kind of coat, and a long almost velvety stem. It does not appear whether this, like *T. caperata*, grows on wood.

T. SCABRA, Berk. and Curt. ;—albida ; pileo anguste flabellato-diviso furcato-lobato, granulato-scabro ; hymenio striato.—Ad terram ? Feejee Islands.

Pileus 1¼ in. high, main divisions much attenuated below, dilated above and incised, with the lobes incised or furcate, rough with little granular warts. Hymenium smooth, striate.—Closely allied to *T. pallida*, Schwein., but distinguished by its rough pileus, which may, however, prove to be an inconstant character.

Hypoxylon pilæforme, Berk. and Curt. ;—globosum, stipitatum et sessile, piceo-laccatum ostiolis prominulis exasperatum, intus album.—Ad lignum. Oahu.

There are but two specimens of this, one of which is depresso-globose, produced at base into a short rugged stem nearly as long as the head, the whole $\frac{3}{4}$ of an inch high; the other sessile, or with a mere rudiment of a stem, and deformed as if by the partial confluence of two or three heads, thus somewhat resembling a small undulate form of *S. concentrica*.—The species is closely allied to *H. polymorphum*, but the sporidia are shorter and thicker. It resembles also *S. obovata*, Berk., and *S. poculiformis*, Mont.

Art. XII.—*On the markings of the Carapax of Crabs;* by James D. Dana.

The areas into which the surface of the carapax of Crabs is subdivided were imperfectly distinguished and named by Desmarest. This author designated the regions according to the internal parts which they covered. But there is a system in the markings which this mode of indicating does not express, and moreover there is a uniformity of character and number which it fails to exhibit. Had the uniformity of number, position and outline been generally recognized, the drawings in this department of Crustacea would not be so commonly incorrect; for even figures from high authority usually misrepresent the character of the surface, and few can be pointed to that are faithful sketches. Moreover these regions, correctly understood, indicate certain homologies in the skeleton of the Decapods. We propose at this time simply to describe the surface markings as they appear.

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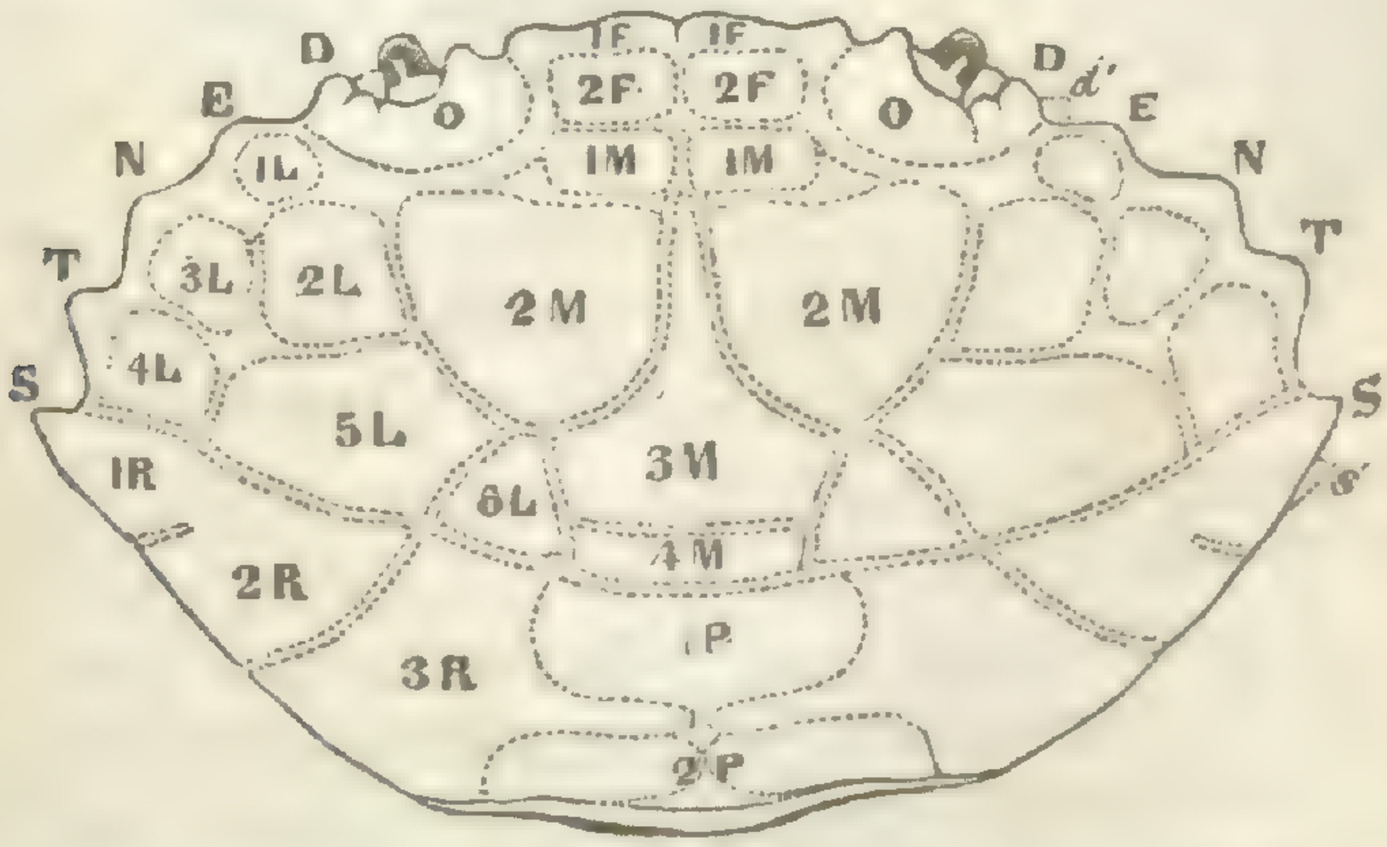

The above figure (fig. 1,) shows the normal number and position as observed in species of the Cancer group. A depression crosses the carapax just back of the middle, and terminates anterior to the last of the normal lateral teeth. Another depression begins in this line either side of the middle and extends

towards the eyes. These depressions divide the carapax into a *medial* region. two *antero-lateral* regions, and a *posterior* region. From the medial, we exclude a frontal portion as a *frontal* region, besides also an *orbital*; and from the posterior two *postero-lateral* regions. Each region has its several subdivisions or areolets.

In the figure referred to, the areolets of the *frontal* region are marked F; of the orbital, O; those of the *medial*, M; those of the *posterior*, P; those of the *antero-lateral*, L; and those of the *postero-lateral*, R:—R being the initial of the last syllable in the word lateral, while L is the initial of the first. The minor subdivisions correspond to prominences or tubercles of the surface and are normally as follows:—

Frontal Region.—1F, the front margin; 2F a prominence just posterior to the front either side of the middle.

Medial Region.—1M, two small anterior prominences, the *præ-medial;* 2M, two large areolets the *extra-medial;* 3M, a central areolet, elongated anteriorly between the areolets 2M, the *intra-medial;* 4M, a transverse areolet just posterior to 3M, the *post-medial.* Two deep punctures usually mark the limit between 3M and 4M, even when there is no depression. 1M is annexed to the medial rather than the frontal region, because it more commonly coalesces with the former, and is a part of it often in general outline.

Antero-lateral Region.—In this region there are normally six areolets and they are often prominent:—1L, near the *first* tooth following the post-orbital. 2L, 3L, posterior to 1L, in a line nearly with the *second* tooth, and 4L, 5L, 6L, between 4M and the *third* tooth.

Postero-lateral Region.—This region on either side consists normally of 3 areolets 1R, 2R, 3R.

Posterior Region.—1P is situated directly behind 4M and is often well circumscribed, and sometimes in shape nearly like 3M reversed and shortened. 2P directly behind 1P, is sometimes simple, but it is more commonly divided in the middle into two areolets. Behind these, is the posterior margin of the carapax.

Orbital Region.—The elevation which encloses the upper side of the orbit is usually divided by sutures into three parts.

The variations in the markings of Crabs arise in the main from the *greater or less prominence of these areolets, their various subdivisions*, or *their obsolescence.* When only a few undulations are apparent on the carapax, a little study with the normal type in view will commonly discover that the system is there although but just apparent; and when once perceived a correct sketch is made without difficulty.

In the *obsolescence* of the areolets, the posterior are the first to disappear, in which case this part of the surface is flat. Next the postero-lateral fail of being distinct. Next 5L and 6L coalesce,

and also 1M and 2M. Next, the posterior of the medial areolets becomes obsolete, and at the same time 5L, 6L disappear, or are indicated only by a slight undulation along the space that ordinarily separates them. The extra-medial may be only circumscribed anteriorly, and the slender elongation of the interno-medial is all that appears of that areolet; next, the remaining antero-lateral areolets may disappear with the frontal, and the surface is then quite smooth. 1L is sometimes indistinct when the other areolets are prominent, though usually it accompanies them.

When 4L, 5L, 6L become indistinct, the transverse depression then prominent instead of passing behind them bends more forward along 3M, and passes anterior to them, and so makes a different subdivision of the carapax in its general aspect and character. In another variety, the prominent transverse depression passes anterior to 5L, but not anterior to 4L, (which may be obsolete,) and has nearly a straight course across the carapax.

In the *subdivision* of the areolets, the first that partake of it are 2M, 5L and 3M. A commencement of this subdivision of 2M (the extra-medial) is very common, and when completed it divides it into two parts longitudinally. This is an important specific character and though hitherto unmentioned in descriptions, it is easily described when a proper notation is adopted. 5L also subdivides from above downward or rather obliquely inward. 3M subdivides at times into 3 parts as shown in figure 2 which includes also 4M. Figure 3 represents another form of this areolet

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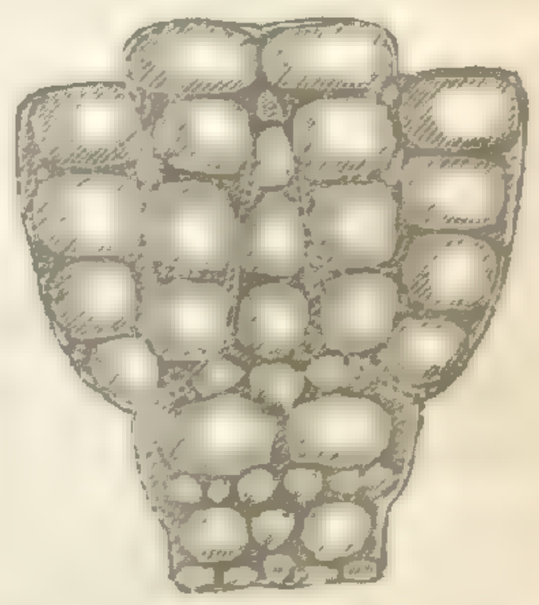


and 4M. In a still further subdivision, each of the areolets is reduced to tubercles, some of them consisting of but one, and others of three or four. Figure 4 represents the medial region of the *Lagostoma nodosa*; the præmedial is a single tubercle; the extra-medial consists of 7 tubercles. 3 in an inner and 4 in an outer series: the intra-medial includes 4 besides some smaller; and the post-medial includes 2 large and some smaller tubercles. When the subdivisions are not carried as far, a portion may be separated anteriorly from each half of 2M, while the rest remains entire.

It is common for 1R to have a tubercle or two on its surface or areolets in the same transverse line with the tooth.

Teeth of the antero-lateral margin.—The teeth of the margin are normally *five* in number, commencing with the post-orbital as the first. These five are represented in figure 1. and are designated in order by the different letters of the word *dentes* (or *dents* in French) D, E, N, T, S. Each tooth is often separated from the adjoining by a minute suture at the bottom of the indentation between them, and hence the letters always mark rather a lobe of the margin than simply a tooth. These teeth vary by obsolescence or subdivision, like the areolets.

In *obsolescence*, the tooth E (second) is the first to disappear, this reducing the apparent number to *four*. Then N fades out, then T, leaving S alone which may also be wanting. Again S is sometimes smaller than T and even disappears.

In the *multiplication* of teeth, there is often, as a first addition, a tooth s' (or two s', s'',) posterior to S. There is often also a tooth (d') between D and E on a lower level than D. But the multiplication is generally dependent on the subdivision of the normal teeth E, N, T, in addition sometimes to S and D,—each of these teeth consisting of two or three teeth, either all equal or one more prominent. In order to determine the normal relations of the teeth when the number is large, we have a guide in the areolets adjoining when they exist; for the areolet 4L (or the range 6L, 5L, 4L,) terminates against tooth or lobe T, having about the same breadth that belongs to this lobe, the depression anterior to 4L corresponding to the fissure between N and T. So 3L (or 3L, 2L) gives the breadth of the normal tooth or lobe N; and 1L, when present, that of E. We thus find that usually when there are seven teeth anterior to S, each E, N, T, are doubled; when eight E, N are doubled, and either T is trebled, or both T and D are doubled.

The medial and antero-lateral areolets may be viewed relatively in two ways. If we compare the medial region as a whole with either antero-lateral as a whole we find a resemblance in general form and subdivisions. Again we observe that the lobe T, areolets 4L, 5L. 6L, 3M or 4M form a transverse zone across the carapax; again lobe N, areolets 2L, 3L, 2M constitute another transverse zone; and lobe 1L and 1M may be viewed as in another zone. These zones are often very distinctly brought out. The lobes E and N are often a little posterior to the areolets adjoining, —or, the line of the lobe and these areolets has a direction a little obliquely backward of a straight transverse line. Again, when the posterior prominent transverse line passes from the limit between T and S inward, anterior to 5L and not to 4L. as alluded to on the preceding page, the apparent zones are nearly straight transverse.

The medial region in the Cancer group is usually narrower than the breadth measured between the outer angles of the orbits: but in the genus Cancer of *Leach* (*Platycarcinus*, M. Edwards),

it is rather wider, owing to the smaller distance between the eyes. The depression limiting on either side this medial region terminates anteriorly in the line of a fissure in the upper margin of the orbit between 1O and 2O.

It is interesting to trace these regions in other families of the Brachyura; but this we reserve for another occasion. Suffice it to say, that in Atelecyclus, which is broader anteriorly than posteriorly, 3M is much elongated, 1P is as long as broad, and there are the normal teeth with others intermediate. In Calappa in which the posterior part of the carapax is broadest, the medial region is comparatively small, and does not reach back quite to the middle of the carapax. 1P is oblong instead of transverse. In the Maiadæ, the medial region is usually large, while the antero-lateral is very narrow anteriorly. The prominent lateral spine or tooth corresponds to S and is usually far back of the middle of the side or margin, and often in the same line with 1P (*cardiac* region of Desmarest). 4M is often obsolete. The deeper transverse depression, limiting the medial region behind, often, instead of extending outward to a point just exterior to S, (obliquely outward and backward in these Crustacea) extends more forward following the outline of the medial region and then bending outward along the depression between 1L and 2L, 3L, or between 2L, 3L, and 5L, 4L. In the former case the region of the tooth E is anterior to the suture or depression, and in the latter, the regions of both E and N. Traces of the depression separating the antero-lateral and postero-lateral regions are also often apparent in this group.

Art. XIII.—*Chemical examination of a Phosphate of Iron, Manganese, and Lithia, from Norwich, Massachusetts*; by W. J. Craw, of the Yale Analytical Laboratory.

This mineral from Norwich, afforded me the following blowpipe characters. Fuses easily in the blowpipe flame with intumescence to a dark bead, feebly magnetic. Dissolves in large quantity in borax yielding a yellowish-red bead, changing after a while to green. On platinum foil with soda gives the reaction for manganese.

The following are the results of two analyses.

	P	Fe	Mn	Al	Li	Ca	Mg	H	
1.	41·35	27·36	24·70	*trace*	2·27	1·97	*trace*	2·07,	insoluble 0·29=100·01.
2.	44·64	26·12	23·30	*trace*	2·20	1·61	*trace*	2·07	" 0·30=100·14.
Oxygen ratio for No. 2.	25·02	7·80	7·07		1·21	0·46			

The specific gravity of the crystal analyzed was 2·876, dried at 212 F.

The manganese was found to be in the state of a peroxyd. The iron was also proved to be mostly if not wholly in the same state of oxydation, and I judge from the condition of the manganese that it was wholly so.

From the second analysis we have as the oxygen ratio for the protoxyds, peroxyds and phosphoric acid, 1·67 : 14·87 : 25·02, equivalent closely to 1 : 9 : 15, corresponding to $1\dot{R}, 3\ddot{R}, 3\ddot{P}$. Supposing the protoxyds absent we have the simple formula $\ddot{R}\ddot{P}$. But including the protoxyds which are beyond doubt essential to the species, we can propose no satisfactory formula.

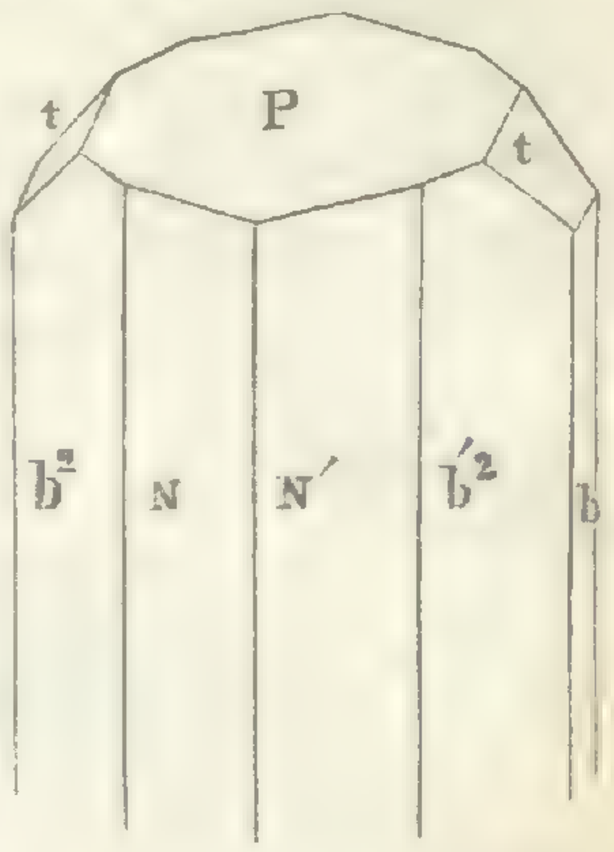
It is possible that the mineral may have undergone alteration by a peroxydation of some or all of the iron or manganese, as happens with other phosphates of these metals; but on this point we cannot be fully assured without farther exploration at the locality. On the supposition that all the metals were originally protoxyds, and have undergone peroxydation, and that the mineral has not lost any essential part of its bases by infiltrating waters, it would afford the oxygen ratio for protoxyds and phosphoric acid, 11·86 : 25·02, or nearly 1 : 2, which would edge this formula $\dot{R}^3\ddot{P}^2$. But in the present state of our knowlgive the formula is altogether hypothetical. In the first analysis, a small proportion of phosphoric acid was not separated from the iron.

Although the species appears to be near Triphyline, the results tend to prove a wide difference from that species rather than an identity with it.

ART. XIV.—*On the Physical and Crystallographic characters of the Phosphate of Iron, Manganese and Lithia, of Norwich, Massachusetts;* by JAMES D. DANA.

THE phosphate of iron, manganese and lithia of Norwich, analyzed by Mr. Craw, occurs in crystals imbedded in quartz along with the crystallized spodumene of that locality; a massive variety has not been observed. The crystals have an iron-black color, and are wholly opaque; hardness 5–5·5; streak brownish-red. They are rather stout prisms, varying from a fourth of an inch or smaller to over an inch in diameter. and often they are regularly terminated at both extremities. The faces are smooth with in general but little lustre, yet somewhat shining. Cleavage imperfect; basal sometimes distinct; also traces parallel to one lateral plane have been observed. The close approximation in the

angle of the prism to that of Staurotide led to the supposition at first that the mineral was a black variety of that species.*



The accompanying figure exhibits the occurring planes. The form is normally a right prism; yet in very many of the crystals the terminal plane is oblique to the lateral, and this obliquity although an irregularity, is not attended with any distortion of the adjoining plane *t*, the upper and lower edges of this plane being parallel notwithstanding the varying inclination of P. The planes N and N′, are similar in lustre, yet according to the various measurements they are unequally inclined to the plane *b*, which fact, if sustained by a farther examination of crystals, would make the form a *rhomboidal* instead of *rhombic* prism and the system of crystallization *monoclinic*. The doubt which remains arises from the variations in the angles among the crystals, a variation which is certainly surprising considering their seeming perfection. As the crystals are wholly imbedded in quartz, the oblique form was the original form, and it was assumed without the assistance of pressure from other crystals, the quartz being massive. The following are the results of the measurement of ten crystals with the common goniometer.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.
N : N′ =	128°	131°–132°	127°–130½°	130½°	126°	134°	128°	130°	130°	° ′
N : b2 =	——	——	113	113	——	108	108	——	——	——
N′ : b2 =	——	121½–122	——	——	——	120	115	120–121	118–119	120 12
P : t =	——	131	129–132	——	——	——	——	——	——	——
N : t =	——	101½–102	——	——	——	——	——	——	——	——
N′ : t =	——	113½	110	110–112	——	——	——	——	——	——
N (or N′?) : b²	159	162	——	——	——	——	——	——	——	——
P on edge N : N′	{	94–97		90		93	100		90	——
	{	86–87	86		86		80	82–83		——

Several smaller crystals afforded for the last angle 90°, leaving little doubt that this is the true angle notwithstanding the discrepancies. The angle of the prism, (N : N′) averages 130°.

Owing to the singular variations of angle exhibited, it is evident that many more crystals must be examined, before their character is fully understood. The angle of the prism approaches that given for triphyline, 132°; but this angle for triphyline was obtained from cleavage planes, and no such cleavages have been distinctly made out in this species. Its peculiarities suggest that the mineral is a new one: but so many species have already been made from altered triphylines that we forbear naming it until farther investigations have been made.

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* See this Journal, [2], x, 121; and also measurements by Mr. Hartwell who obtained with Mr. E. Hitchcock, Jr., the first specimens, same volume, page 265.

ART. XV.—*Notice of the discovery by Walter Mantell, Esq., of Wellington, in the Middle Island of New Zealand, of a living specimen of* NOTORNIS, *a bird of the Rail Family, allied to Brachypteryx, and hitherto known to naturalists only by its fossil remains.* (In a letter from Dr. MANTELL to the Senior Editor.)

I AM sure you will be gratified to learn that the perseverance of my son, Mr. Walter Mantell, now of New Zealand, has been rewarded by the discovery of a living specimen of a genus of *Rallidæ*, of which, crania with the humerus, sternum, and other parts of the skeleton, were found by him associated with remains of the colossal Moas, in the sand deposits near Waingongoro, on the western shores of the North Island. The fossil bird was referred by Professor Owen to a new genus, which he named *Notornis*, (Southern bird), with the specific title *Mantelli*, in commemoration of the discoverer, (see Zoological Transactions, vol. iii.) Now there was a traditional story rife among the natives, that contemporaneously with the gigantic birds, (Dinornis, Palapteryx,) there existed several small birds of various kinds; and a species of *Swamp-hen* was particularized as having been abundant down to a late period, but was supposed to have been long extinct, its extermination being attributed to the wild cats and dogs, which at the present time are a pest to the colonists, destroying the young poultry and other domestic birds, as well as the indigenous species. This rail was said to be of the size of a small turkey, of a black color, without wings, with red beak and legs: no specimen had been seen or heard of since the English colonized the Island. The South Islanders called the bird "*Takahé*," the North Islanders "*Moho*." On a second visit to the southern parts of the Middle Island, my son obtained from some sealers a fine example of the supposed extinct *Notornis*. It appears that these men when frequenting the coasts of Dusky May, (on the S. W. extremity of the Middle Island), in search of seals and other game, perceived on the snow, which thickly covered the ground, the track of a large and strange bird, which they followed a considerable distance, and at length caught sight of the object of their search, which fled with great rapidity from the pursuit of their dogs, and was driven up a gully in a sound behind Resolution Island, and caught alive. It screamed loudly and fought and resisted fiercely upon being captured. It was kept alive a few days on board the schooner, and then killed and roasted, the skin with the head and legs only being preserved. This was fortunately obtained while fresh and in good condition by my son, and thus, perhaps, the last of the race—not of *Mohicans*, but of *Mohos*—was preserved for the naturalists of Europe.

This beautiful bird is about two feet high, and much resembles in its general form the *Porphyrio melanotus*, but is generically distinct; the characters predicated by Professor Owen from the fossil skull and bones, being well exhibited in this recent example. The beak is short and strong, and was, as well as the legs, when this animal was alive, of a bright red color. The neck and body are of a dark purple, the wings and back being shot with green and gold. The wings are short and rounded, and remarkably feeble, both in structure and plumage. The tail is very scanty, and white beneath. Mr. Gould, an eminent ornithologist, (author of the Birds of Australia, &c.), to whom I have given the privilege of figuring and describing it, as a tribute of respect for his indefatigable and beautiful researches in that department of natural history, confirms the opinion that it is identical with the fossil: this, then, is a recent example of the *Notornis Mantelli*, a bird coëval with those marvelous bipeds—those giants of their class—whose stupendous proportions and mighty strength are celebrated in the songs and traditional tales of the New Zealanders, and whose bones and even eggs have been transmitted to Europe, and excited the wonder and delight of the philosophers and the multitude.

In a letter announcing this discovery, my son writes, that he had sent me both recent and fossil specimens of "*a genus of bird hitherto unknown to naturalists*," and though he had not found "a live Moa, he had at least found a living contemporary." It is possible that another specimen of Moho may be caught, sooner or later, yet from all I can gather from persons who have long resided in various parts of the New Zealand Islands, there is greater probability that this may be the last ever seen alive. My son also sent me other fine skins; one of that marvelous New Zealand bird, the *Strigops*—which blends the characters of the owl and parrot, two of *Neomorpha*, and one of *Apteryx australis*, and *Ap. Owenii*: the last is of great rarity: I believe this is but the third specimen sent to England. I shall let the British Museum have it, as there is no example of this species in our national collections. The *Notornis* and the other birds I shall retain.

You will at once perceive the importance of this discovery in its bearing on the problem as to the contemporaneity of the Moa and its kindred with species of which there are still living representatives: it confirms those general inferences as to the probable age of the ossiferous deposits of New Zealand, cited in my Memoirs published in the Geological Journal, and Pictorial Atlas, and also in the lecture delivered in Edinburgh, before the British Association of Science. My son, at the date of his last letter, (May, 1850,) was about to depart once more for the bone-beds on the western shores of the North Island, and with the especial object of exploring certain caverns in the limestone rocks of that

district, which are said to contain bones of Moas and other animals.

A friend of mine lately received a letter, dated October, 1849, from Dr. Thompson, surgeon of the 58th regiment, now at Auckland, in which the writer states that having heard from —— Servantes, the native interpreter, of caves containing birds' bones, he accompanied the latter in search of the place, and was rewarded by obtaining several skulls and mandibles. He observes: "The beak is not like the *Keiri*, (Apteryx), but resembles that of the ostrich or Cassowary. The cave is on the west side of the North Island, in the limestone formation which extends along the coast. The country around is wild, and there are many similar caverns which we were told had birds' bones in them. The popular opinion among the natives is, that the country was once set on fire by an eruption from the volcano of Tongariro, and that all the Moas fled to the caves for refuge, and there perished. This story will do well for the North Island; but how were they extinguished in the Middle Island, where there are no active volcanoes?" In reference to this remark of Dr. Thompson, it is however not a little curious that the tradition of extensive conflagrations over the Middle Island, is confirmed by the state of the subsoil; for my son found that the now grassy plains, where our modern "Canterbury Pilgrims" have fixed their tents, bore evidence beneath the turf of former forests that had been consumed by fire, the charred stumps of the trees remaining in situ. Even on the swamp or morass at Waikonaiti, where my son obtained the remarkable pair of perfect feet, there were traces of the same catastrophe: everywhere, he says, there were charred stumps of trees which had been burnt down to the ground. But it was beneath this superficial covering that the bones of the Moas were entombed; a forest had grown over the ancient swamp, and has been consumed by a conflagration of comparatively recent date; and now the sea covers the site except at low water. I see that a paper by Prof. Owen, on skulls of the *Palapteryx ingens*, is announced for the first meeting of the Zoological Society: I think it probable that these are the specimens collected by Dr. Thompson, and presented to the Governor, Sir George Grey. I intend sending a brief notice of the discovery of the Notornis, to the Zoological Society, as the subject was first announced in the transactions of that body. I may also add that among the fossil shells collected by Mr. Walter Mantell, in the North Island, are species of *Cucullæa*, one apparently identical with *Cucullæa* ***decussata*** of England.

My recent acquisitions have not, however, been confined to Antipodean varieties. From the Wealden and my own geological domain, as well as my native soil, I have obtained some highly interesting and novel remains of the colossal reptiles that

were contemporaries of the Iguanodon: of these I hope to give a full and detailed account ere long. I have too at last discovered abundance of fossil cones, the fruit or seed vessels of the fir-trees composing the forests of the Wealden, and of which, as you will remember, Brook Point in the Isle of Wight, affords a notable illustration. I have also a beautiful fossil palm-leaf from the tertiary strata of the Isle of Wight, being the first species of this kind found in England.

Chester Square, Pimlico, November 8, 1850.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

[Note.—It is my intention in future to prepare for the columns of this Journal abstracts of the more important physical and chemical memoirs contained in foreign scientific journals, accompanied by references, and by such critical observations as the occasion may demand. Contributions of a similar character from others will of course not be excluded by this arrangement, but I shall hold myself responsible only for those notices which appear over my initials.

New York, Jan. 1st, 1851. Wolcott Gibbs.]

1. *On the penetration of Magnetism into soft iron*; by Dr. von Feilitzch in Greiswald.*—The researches of Lenz and Jacobi† on the magnetization of soft iron appeared to have demonstrated, 1st, that in massive iron cylinders of equal length and of more than one-third of an inch in diameter, the intensity of magnetism produced by currents of equal force and traversing spirals of an equal number of windings, is proportional to the diameters of the cylinders; and 2d, that the magnetism induced in soft iron by galvanic currents is proportional to the force of the inducing current. From the first of these laws it would follow that the magnetic tension of the iron would exist only upon its surface, and would not penetrate the interior of the mass; the second law would exclude the existence of a point of saturation or of maximum magnetic intensity. These considerations induced the author to investigate the subject anew, and the results of his observations are contained in the memoir before us. The force of the current used was in each case measured by a method described by the author in a former memoir,‡ the principle of which consists in equilibrating the deflecting force of the current upon a magnetic needle by means of a permanent magnet, the magnetic intensity of which has been previously referred to absolute measure. The needle is placed upon the middle of a scale at right angles to the magnetic meridian, the center of the needle forming the 0 point of the scale. A helix of copper wire the length of which is represented by $2a$, (102^{mm}), is placed upon one side of the needle,

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* Pogg. Ann. lxxx, 321. † do. xlvii, 225. ‡ do. lxxviii, 21.

the magnetic bar whose length is 2α, ($91{\cdot}0^{mm}$), upon the other. The helix traversed by the current and the bar may be slid upon the scale till the sum of their deflecting actions upon the needle is 0; the distances of their centres, r and ϱ, from the 0 of the scale may then be read off, and the magnetic force J^1 of the spiral or of a soft iron bar in its axis, determined by the formula

$$J^1\left(\frac{1}{(r-a)_2}-\frac{1}{(r+a)^2}\right)=J\left(\frac{1}{(\varrho-\alpha)^2}-\frac{1}{(\varrho+\alpha)^2}\right)$$

where J, which in comparative experiments may be regarded as=1 represents the quantity of magnetism in the steel bar. The author first determined the force of the current alone, then introduced a bar of soft iron or an iron cylinder into the axis of the spiral and measured the intensity of the induced magnetism, directing the two ends of the bar alternately toward the 0 point of the scale, the difference between the magnetic intensity of the spiral alone and that of the spiral and iron core together, gave the magnetic intensity of the core. A number of hollow iron cylinders, fitting closely into each other, were prepared, and by means of these and the method of measurement already described, the author arrived at the following conclusions:

(1.) Electro-magnetism penetrates into the interior of soft iron.

(2.) The more powerful the inducing current the deeper the penetration.

(3.) Every layer of the soft iron has a point of saturation.

(4.) The magnetism of hollow and massive cylinders of the same kind of iron is of equal intensity, provided that there be a sufficient mass of iron present for its evolution.

And furthermore that

"The density of the electro-magnetism upon the surface of soft iron is the same for all currents whatever may be their force, and may be expressed by the number 7·200."

[The researches above mentioned would appear to lead to the conclusion that every bar of iron magnetized by induction must have a point of saturation, at which the magnetism of every layer in the substance of the bar would equal that upon the surface, yet it is probable that this point of saturation could never be attained by any force of current which we are able to command, at least in the case of bars of any considerable diameter.]

2. *On the law for the intensity of Magnetism induced in soft iron by galvanic currents.*—Buff and Zamminer have undertaken an experimental investigation of the law of Lenz and Jacobi, that the intensity of the magnetism induced in soft iron by galvanic currents is proportional to the force of the current. Müller in Freiberg has recently called this law in question, and asserts, that for every bar there is a point of saturation beyond which the intensity of the magnetism is not increased. The method of investigation pursued by the authors is the same as that used by Müller and in an earlier and unpublished series of experiments by Buff. The current passes through the ring of a tangent compass and through a magnetizing spiral or helix, into the axis of which iron cores of different dimensions may be inserted. A small magnetic needle is placed horizontally in such a position that the axis of the iron core

when produced and at right angles to the meridian passes through the center of the needle. The force of the current is varied by means of a Wheatstone's rheostat which forms part of the circuit. If φ and φ' represent the angular deviations of the two magnetic needles, then for the same series of experiments $\frac{\tan \varphi}{\tan \varphi'}$ must be constant in case the assumed proportionality between the intensities of the inducing current and of the induced magnetism, holds good. The iron bars employed were cylindrical, and their surfaces were turned smooth to remove the layer hardened by hammering. The results of numerous careful determinations show that the ratio $\frac{\tan \varphi}{\tan \varphi'}$ is *ceteris paribus* constant, and consequently confirm the law of Lenz and Jacobi. [The authors attribute the opposite results obtained by Müller partly to the manner in which the investigation was made, and partly to the want of softness in the iron employed, a portion of magnetism being always retained, which Müller does not appear to have sufficiently guarded against by interrupting and reversing the current. Nevertheless the experiments of von Feilitzch yield some support to Müller's view, and certainly render a thorough investigation of the whole subject desirable.]

3. *On the action of heat and alkaline bases upon the homologues of Acetic Acid.*—Cahours has studied the products of the simultaneous action of heat and alkaline bases upon the homologues of acetic acid. Pelargonic acid $C_{18}H_{18}O_4$, was distilled with four times its weight of potash-lime. A limpid amber colored liquid was obtained, together with a considerable quantity of gas possessing a high illuminating power, and there remained in the retort a mixture of caustic alkali and of alkaline carbonates. The gas obtained was passed through bromine which absorbed a large proportion, the part which escaped possessed but a feeble power of illumination when compared with that of the raw product. The brominated liquid was found to contain three distinct products in variable proportions:

$C_4H_4Br_2$=4 vol. vapor boiling at 130° C.
$C_6B_6Br_2$=4 vol. vapor boiling at 144° C.
$C_8H_8Br_2$=4 vol. vapor boiling at 160° C.

The gas absorbed consists therefore of olefiant gas, (acetene), propylene C_6H_6, and butyrene C_8H_8; the unabsorbed portion consisted of hydrogen and marsh gas (palene). The liquid condensed began to boil at 105° to 106°, the last portions distilled between 135° and 140°; the portion boiling between 106° and 110° possessed a density of 0·708, at 16°, the density of its vapor was 3·954, which leads to the formula $C_{16}H_{16}$=4 vol. vapor. With bromine this liquid gave a heavy fluid compound, $C_{16}H_{16}Br_2$=4 vol. vapor, which is therefore a homologue of the preceding. The author has obtained similar results with caprylic, enanthylic, margaric and ethalic acids; all of these gave liquid carburets of hydrogen of the form $C_m H_m$ as well as the gases C_4H_4, C_6H_6, C_8H_8. After recalling the analogous results obtained by Hofmann with valeric acid, the author concludes, that setting out with valeric acid the homologues of marsh gas (palene) do not possess

sufficient stability to resist the temperature at which the decomposition of the acid takes place, and that they are therefore resolved into marsh gas, hydrogen, and a series of hydro-carburets of the form $C_m H_m$.—*Comptes Rendus, July 29th*, 1850.

4. *On the products of the action of chlorine upon Propylene.*—CAHOURS has also examined the products of the action of chlorine upon propylene, C_6H_6. When chlorine and the gas obtained as above by the decomposition of pelargonic acid are caused to meet in a large receiver, white vapors are seen, and a liquid condenses upon the walls of the receiver which contains as its chief constituent a compound analogous to the liquor of the Dutch chemists ($C_4H_4Cl_2$) and represented by the formula $C_6H_6Cl_2$. This liquid, the discovery of which is due to Reynolds, furnishes the starting point of the author's investigations. Submitted to the action of a current of chlorine a series of liquids is obtained, represented by the following formulæ:

$C_6H_6Cl_2$	boiling at	104°	Density	= 1·151 = 4	vol.	vapor.	
$C_6H_5Cl_3$	"	170°	"	= 1·347 = 4	"	"	
$C_6H_4Cl_4$	"	195°–200°	"	= 1·548 = 4	"	"	
$C_6H_3Cl_5$	"	220°–225°	"	= 1·548 = 4	"	"	
$C_6H_2Cl_6$	"	240°–245°	"	= 1·626 = 4	"	"	
C_6HCl_7	"	260°	"	= 1·731 = 4	"	"	
C_6Cl_8	"	280°	"	= 1·860 = 4	"	"	

These compounds distilled with an alcoholic solution of potash yield a new series of homologues with those derived in a similar manner from the liquor of the Dutch chemists and its derivatives by substitution. We thus obtain the compounds C_6H_5Cl, $C_6H_4Cl_2$, $C_6H_3Cl_3$, $C_6H_2Cl_4$, C_6HCl_5, C_6Cl_6, each of which corresponds to 4 vols. vapor. By similar processes, M. Cahours has obtained several members of the two corresponding bromine series, viz.: $C_6H_6Br_2$, $C_6H_5Br_3$, $C_6H_4Br_4$, $C_6H_3Br_5$, and C_6H_5Br, $C_6H_4Br_2$, $C_6H_3Br_3$. The readiness with which these last series are obtained led the author to examine the products of the successive action of bromine and of an alcoholic solution of potash upon the brominated Dutch liquor $C_4H_4Br_2$; bromine compounds corresponding to the two chlorids C_4Cl_4 and C_4Cl_6 could not be obtained, but the two series following were procured in the manner stated. $C_4H_4Br_2$, $C_4H_3Br_3$, $C_4H_2Br_4$, C_4HBr_5 and C_4H_3Br, $C_4H_2Br_2$, C_4HBr_3. Similar compounds were produced by the action of bromine upon other hydro-carburets of the series $C_m H_m$, as for instance, butyrene, anilene, paramilene, &c.—*Comptes Rendus, August 26th*, 1850.

5. *On the combinations of Iodine and Phosphorus.*—CORENWINDER has succeeded in preparing definite and crystalline combinations of iodine and phosphorus by successively dissolving the two substances in sulphuret of carbon, and cooling the solution artificially. Two eq. of iodine and one eq. of phosphorus give large orange-red prismatic crystals of an iodid, represented by the formula PhI_2; this compound fuses at about 110°, changes in the air, and volatilizes at a higher temperature. Three eq. of iodine and one eq. of phosphorus yield large irregular crystals of a fine red color, and apparently consisting of hexagonal plates; these crystals by distillation give a mass capable of

crystallizing by fusion in very long prisms. The iodid PhI_3 fuses at 55° C. and is decomposed by water with evolution of H I. When five eq. of iodine and two of phosphorus are employed, we obtain at first crystals of PhI_2, and then those of PhI_3. By using the sulphuret of carbon as a solvent, the author obtained in crystals many other compounds, such as the perchlorid and the sulphuret of phosphorus.—***Comptes Rendus, August 5th, 1850.***

6. *Preparation of Chlorate of Potash.*—Calvert has given a new mode of preparing chlorate of potash which offers great advantages over those now in use. One equivalent of caustic potash is to be dissolved in so much water that the solution has a density of 1·110; six equivalents of quicklime are to be added, and the whole gradually heated to 50° C. A rapid current of chlorine is then to be passed through the solution till it becomes saturated, the chemical action raising the temperature to 90°; the liquid is to be filtered, evaporated to dryness, the residue dissolved in boiling water, and the solution allowed to cool, when the chlorate is obtained in crystals.—*Comptes Rendus*, xxx, 656.

[The employment of quicklime in connection with potash was first suggested by Graham; the two substances were however mixed when dry, and the process is believed to have been unsuccessful upon the large scale.]

7. *Iodine.*—Bussy has discovered iodine, and Mène bromine, in the ammoniacal liquids obtained in the manufacture of gas.—*Comptes Rendus*, xxx, 612, 537.

Lamy, Meyse, Chatin and Personne have found iodine in various fresh water plants, in Confervæ, and in the ashes of the beet root.—*Comptes Rendus*, xxx, 463, 478, 475.

8. *Absorption of carbonic oxyd by an ammoniacal solution of subchlorid of copper.*—Stas, Doyère and Leblanc had observed the absorption of carbonic oxyd by an ammoniacal solution of subchlorid of copper. Leblanc has studied the subject more particularly, and obtained the following results. A solution of subchlorid of copper in chlorohydric acid absorbs oxyd of carbon rapidly, and in considerable quantity, though with but slight elevation of temperature. The ammoniacal subchlorid absorbs the gas in the same manner, and the quantity absorbed is the same for the same quantity of copper dissolved. The acid solution of the subchlorid, after being saturated with the gas, may be diluted with water without precipitation and without evolution of gas. Other salts of the suboxyd of copper were found to absorb the gas in a similar manner; ebullition and a complete vacuum expel the oxyd of carbon, but the author did not succeed in obtaining an isolated compound, though the quantity of the gas absorbed by a cupreous solution appeared to be one eq. for one eq. of copper dissolved. The analogy between this reaction and the absorption of nitric oxyd by protosalts of iron is obvious; salts of iron and tin, however, were found to have no action on the oxyd of carbon.—*Comptes Rendus*, xxx, 483.

9. *On the coloring principles of Madder.*—Wolff and Strecker have contributed a memoir on the coloring principles of Madder which offers many new points of interest. A careful study of the madder itself as well as comparative experiments on materials prepared by Robiquet, Schunck, and Debus, led them to admit the existence in

madder of two red coloring principles, viz.: alizarin and purpurin, and of yellow or orange substances which perform no important part in the operation of the dyer. Alizarin, as prepared by a new process resembling that of Schunck, but for which we must refer to the original paper, presents itself in two different forms, viz., as hydrous and as anhydrous. The hydrated alizarin is obtained in scales which resemble aurum musivum; the anhydrous exhibits a red color, with a more or less distinct yellow tinge, according to the thickness of the crystals. On heating it fuses and sublimes in orange-colored needles, a small portion at the same time undergoing decomposition. It is with difficulty moistened by cold water, but dissolves in boiling water with a deep yellow color. The smallest trace of alkali colors the solution red. It is soluble in alcohol and ether; the alcoholic solution is reddened by alkalies, the etherial on the contrary remains unchanged, as the red alkaline compound is insoluble in this medium. Alkalies readily dissolve alizarin; the solution in caustic soda or potash when moderately concentrated is red by transmitted and blue by reflected light; by dilution the liquid assumes a uniform violet tint. In alkaline carbonates, alizarin is soluble with a color resembling that of litmus, but without a blue reflection. The authors refer the differences in color of these solutions to the formation of different combinations of alizarin and alkali. Schunck represented the constitution of alizarin by the formula $C_{14}H_5O_4$; Debus by $C_{30}H_{10}O_9$; the authors propose the formula $C_{20}H_6O_6$, and show that it accurately corresponds with the analytical results of both Schunck and Debus. The hydrate of alizarin is represented by $C_{14}H_5O_4+4HO$. The following table represents the constitution of the principal compounds of alizarin:

Alizarin, oxyd of lead,	$2(C_{20}H_5O_5)+3PbO$	(Schunck.)
Alizarin, oxyd of lead,	$3(C_{20}H_5O_5)+4PbO$	(Debus.)
Alizarin-lime,	$2(C_{20}H_6O_6)+3CaO+3$ aq.	
Alizarin-baryta,	$C_{20}H_6O_6+2BaO$	
" "	$2(C_{20}H_6O_6)+3BaO+3$ aq.	
" "	$3(C_{20}H_6O_6)+2BaO$	

By the action of different oxydizing agents upon alizarin, an acid is obtained which was described by Schunck under the name of alizaric acid. Laurent and Gerhardt pointed out the resemblance between alizaric and phthalic acid, and asserted the identity of these acids. Wolff and Strecker have placed the identity of the two acids beyond a doubt, and represent the conversion of alizaric into phthalic acid by the equation.

Alizaric acid. Phthalic acid. Oxalic acid.

$$C_{20}H_6O_6+2HO+O_8=C_{16}H_6O_8+C_4H_2O_8.$$

They further demonstrate that the chloro-naphthalic acid of Laurent is identical with chlorinated alizarin, as may be seen by the following formula.

Alizarin,	$C_{20}H_6O_6.$
Chloro-naphthalic acid,	$\left.\begin{matrix}C_{20}H_5\\Cl\end{matrix}\right\}O_6.$

Laurent long since showed that chloro-naphthalic acid by oxydation yields phthalic, oxalic, and chlorohydric acids. The authors however, did not perfectly succeed in transforming chloro-naphthalic into alizarin, either by Melsen's or by Kolbe's method of replacing chlorine by hydrogen; they invite the attention of other chemists to the subject, and point out the practical advantage which would accrue from a method of converting naphthalin into alizarin.

Purpurin crystallizes from its solution in *strong* alcohol in red needles; from weak alcohol on the contrary, in fine, soft, orange-colored needles, which dry to a felted mass. The orange-colored needles contain water which they lose at 100°. Purpurin is more easily soluble in water than alizarin, and with a redder color. It fuses by heating and sublimes leaving some carbon; its solution in caustic potash is cherry red without the blue reflection characteristic of alizarin. The authors propose for purpurin the formula $C_{18}H_6O_6$, in place of that of Debus $C_{15}H_5O_5$. The hydrate has the formula $C_{18}H_6O_6+HO$. Purpurin contains therefore 2 eqs. less of carbon than alizarin and it is highly probable that the latter may be converted into the former by oxydation. As shown by the equation,

$$C_{18}H_6O_6+HO+O_5=C_{16}H_6O_8+C_2HO_4.$$

Purpurin with nitric acid yields phthalic and oxalic acids.—*Annalen der Chemie und Pharmacie*, lxxv, 1, *July*, 1850.

10. *Action of Sulphite of Ammonia.*—Piria has found that sulphite of ammonia acts energetically upon various organic substances containing (NO_4), as for example nitro-benzoic, nitranisic and nitro-salicylic acids. By the action of a concentrated solution of the sulphite upon an alcoholic solution of nitro-naphthaline two new isomeric acids are obtained in combination with ammonia. These the author terms naphthionic and thionaphthamic acids; supposed anhydrous they are represented by the formula, $C_{20}H_8NS_2O_5$.

Naphthionic acid is white, nearly insoluble in cold water and alcohol, more soluble in boiling water from which it crystallizes by cooling in acicular crystals of a satiny lustre. The naphthionates are all soluble and crystallize easily. Thionaphthamic acid cannot be obtained in a free state but forms perfectly definite salts; those of potash, soda and ammonia are soluble and crystallize. When we attempt to isolate the acid it is resolved into sulphuric acid and naphthalidin $C_{20}H_9N$, which last may be obtained easily and in abundance by distilling a thionaphthamate. The author has found that naphthalidin is converted by perchlorid of iron, and by oxydizing agents into *naphthaméine*, a new substance of a fine blue color, the formula of which is not given. —*Comptes Rendus*, xxxi, 489, 30*th Sept.*, 1850.

[*Note.*—The naphthionic and thionaphthamic acids of Piria may be regarded as "*amic acids*" analogous to aminsulphuric acid, $SO_3,HO+SO_2NH_2$ or $S_2O_5NH_2+HO$, oxamic acid, &c. Piria's acids on this view would be represented by the formula, $SO_3HO+SO_2,NC_{20}H_8$; if naphthalidin be considered as ammonia in which one eq. of hydrogen is replaced by one eq. of $C_{20}H_7$, the body $NC_{20}H_8$

may be regarded as NH_2 in which the same substitution has occurred. The isomerism of the two acids may be due to the existence of two isomeric radicals $C_{20}H_7$.]

11. *On Nitro-hippuric acid.*—BERTAGNINI has found that nitro-benzoic acid taken into the stomach passes into the urine in the form of nitro-hippuric acid, $C_{18}H_8N_2O_{10}$, which has not hitherto been described. The author obtained the same substance however by acting on hippuric acid with a mixture of fuming nitric and sulphuric acids, and found that when heated with chlorohydric acid it was resolved into glycocoll and nitro-benzoic acids.—*Comptes Rendus*, xxxi, 470, *Sept. 30th.*

12. *Action of cyanhydric acid upon aldehyde ammonia.*—STRECKER has studied the action of cyanhydric acid upon aldehyde ammonia. When an aqueous solution of cyanhydric acid and aldehyde ammonia is evaporated upon a water bath, a brownish colored thick syrup remains, which after a few hours solidifies to a mass of fine needles. The new substance possesses basic properties but has not been farther studied. When two parts by weight of aldehyde ammonia and one part by weight of anhydrous prussic acid are mixed in solution, chlorohydric acid added in excess and the whole distilled, a liquid is obtained free from aldehyde ammonia but containing chlorohydric acid and a small quantity of prussic and formic acids. The liquid in the retort gives by evaporation and crystallization, sal-ammoniac and a mother-liquor containing a new substance, alanin. Alanin crystallizes from a warm solution on cooling in colorless, usually acicular, prisms, often of considerable size; the crystals are hard and crack between the teeth; they are soluble in water, slightly soluble in alcohol, insoluble in ether; the aqueous solution has a sweet taste, does not change vegetable colors, and gives no precipitate with the ordinary reagents. Above 200° alanin sublimes and condenses in fine snowy crystals; its constitution is represented by the formula $C_6H_7NO_4$, and it is consequently a homologue of glycocoll; the following equation represents its formation

$$C_4H_4O_2+C_2NH+2HO=C_6H_7NO_4.$$

Strecker observes that alanin has the same formula as urthethan, lactamid and sarkosin, from which however its chemical and physical properties sufficiently distinguish it; it combines with acids to form crystalline compounds, as well as with the oxyds of silver, copper, lead, and barium; in these respects therefore it resembles glycocoll. Heated with caustic potash, alanin yields ammonia and hydrogen, the residue distilled with sulphuric acid gives acetic acid. With peroxyd of lead alanin gives carbonic acid, aldehyde, and ammonia; when a current of nitrous acid (NO_3) is passed into an aqueous solution of alanin, nitrogen is evolved and *lactic acid* remains in the same modification with that which is obtained from sugar. The following equation,

$$C_6H_7NO_4+NO_3=C_6H_6O_6+2N+HO,$$

represents the reaction.—*Annalen der Chemie und Pharmacie*, lxxv, 1, *July*, 1850.

WOLCOTT GIBBS.

13. *On the Nitroprussids, a new class of Salts;* by Dr. LYON PLAYFAIR, (Phil. Trans. for 1849, part 2d; L., E. and D. Phil. Mag., March, April, and May, 1850.)—Hitherto but little has been known in regard to the action of nitric acid upon the ferrocyanid of potassium. The most remarkable observation on the product of this reaction was that when added to a solution of alkaline sulphid, a magnificent purple color was produced.

Dr. Playfair in making a new investigation of this reaction, found that nitric oxyd was only given off when the decomposition was violent, while under more favorable circumstances it disappeared, leading to the belief that it exercised an important influence in the transformation. This was confirmed by further experiment. Nitric oxyd was absorbed by cyanid of potassium, which after the addition of protosulphate of iron, produced the characteristic purple color with alkaline sulphids. Ferrocyanid of potassium produced the same result, provided enough acid to take up the alkali had been previously added, and the mixture heated. Pure hydro-ferrocyanic acid by similar treatment furnished the acid of the new class of salts to which the name of *nitroprussids* is given.

These observations are valuable as giving an idea of the nature of the new salts, for the economical production of which, the following process is recommended. Common nitric acid is diluted with its bulk of water, and the quantity required to neutralize 53·3 grs. carb. soda (1 equiv.) is ascertained. Five such portions are to be used for every equiv. or 422 grs. of ferrocyanid of potassium—the whole of the acid being poured at once upon the powdered salt, which gradually dissolves into a coffee-colored liquid with the evolution of cyanogen, hydrocyanic acids, together with some nitrogen and carbonic acid. When the solution is complete, the whole is digested in the water-bath until the precipitate with sulph. iron is dark-green or slate colored. The solution is now allowed to cool—nitrate of potash crystallizes together with a white substance which proves to be *oxamid*. To form nitroprussid of sodium, which is more readily procured than the salt of potassium, the solution is neutralized with carb. soda, boiled and filtered from the dark-green or sometimes brown precipitate which forms. Concentration produces more of the latter substance; after another filtration the nitrates are allowed to crystallize. The liquid is now evaporated on the sand bath, and the nitroprussid of sodium removed as fast as it forms, the nitrates remaining being more soluble in the hot liquid. The salt may be obtained pure by crystallization from a hot solution.

Nitroprussid of sodium forms ruby-red prisms not unlike those of red prussiate of potash; it is not deliquescent, although soluble in two and a half pints of water at 60°, and still more readily in hot water.

The chief characteristic of the salts is the above named reaction with soluble sulphids. The author proposes this as the most delicate test known for that class of compounds. The beautiful purple color is **however very fugitive.**

The precipitates formed by the nitroprussids are salmon-colored in the protosalts of iron, light green with salts of copper, and not very striking with several other metals. With persalts of iron, salts of tin and mercury, and neutral salts of lead, no change is produced.

The nitroprussids are very liable to change, and hence the determination of their true formula is a matter of some difficulty. The industrious and accurate author records over one hundred analyses of the salts on the products of their decomposition. The analyses most trust worthy agree very nearly in assigning a composition which aside from its apparent complexity, seemed so improbable, that they have been repeated under every variety of circumstance with the view of obtaining simple results, which have however obstinately refused to show themselves.

The formula thus obtained is $Fe_5C_{24}N_{15}O_3R_5$. The author would have preferred the ratio Fe_5 to C_{25}, but, as we have said, the analyses would not allow of it. Various conjectures are given as to the rationale of this curious composition, upon which point another paper is promised.

We are indebted to Gerhardt for a series of formulas by which under his genus of Polycyanid, we can include without difficulty all the various compounds which have caused so much trouble to chemists, and to explain which at least two hypothetical radicals are generally required. Let $Fe\beta$ stand for iron with two-thirds its usual equiv., as in peroxyd, perchlorid, &c., and we have the following formulas:

Ferrocyanid,	$C_{12}(Fe_2R_4)N_6$
Prussian blue,	$C_{12}(Fe_2Fe\beta_4)N_6$
Ferridcyanid,	$C_{12}(Fe\beta_3R_3)N_6$
Turnbull's blue,	$C_{12}(Fe\beta_3Fe_3)N_6$

By similar experiments we can denote the composition of Everitt's salt, the complex ferrocyanids and the other varieties of Prussian blue. By doubling the equiv. to avoid fractions, we have the nitroprussids as follows:

Nitroprussids, $C_{24}(Fe\,Fe\beta_6R_5)N_{12}+3NO.$

Fe and $Fe\beta_6$ or Fe^{12}_3 being together equal to Fe_5, as given in the analysis. The only difficulty is in the relation of 3NO. This from its somewhat basic character may be superadded to the polycyanids as NH_3 is to the ordinary cyanids. Possibly there may be some connection between this and the absorbtion of NO_2 by protosalts of iron. At any rate the formula expresses a relation to known compounds, and accounts remarkably well for some phenomena in the decomposition of the nitroprussids. G. C. SCHAEFFER.

14. *On a new property of Carbonic Oxyd*; by F. LEBLANC, (Comptes Rendus, April, 1850.)—In absorbing oxygen from a gaseous mixture by the ammoniacal subchlorid of copper, it was noticed that a large quantity of carbonic oxyd was also dissolved. The same reagent when protected from the action of the air was found to absorb the gas readily and still retain its property of becoming blue on exposure to the air or oxygen. G. C. S.

The solution of subchlorid of copper in muriatic acid possesses the same properties, absorbing the gas as readily as solution of caustic potash absorbs carbonic acid. It is remarkable that after saturation the subchlorid is not precipitated by dilution with water.

All attempts to procure a solid compound of the gas and salt failed. The quantity taken up was one equivalent of CO for one equivalent Cu. Cyanogen produces in the same solution a chrome yellow precipitate, which changes on exposure to the air. G. C. S.

15. *On the Aërometric Balance, an instrument for measuring the Density of the air in which it is placed*; by Prof. POTTER, (L., E.

and D. Phil. Mag., Aug., 1850.)—This instrument is proposed as a means for detecting local variations in the density of the air, dependent upon the particular proportions of its constituent gases or vapors. The principle of its construction is similar to that of the well known air-pump experiment, in which the equilibrium between a solid ball and hollow bulb is disturbed when placed under an exhausted receiver.

In the practical construction of the instrument a closed glass bulb is suspended from a hook carrying an agate plane, which rests on a knife edge at the short arm of a beam, the fulcrum of which is provided with a knife edge, &c., as in an ordinary balance, while the long arm terminates in a vernier, the angular deviation being measured on a graduated arc—forming in fact a species of bent-lever balance, the arms however being nearly in a line.

The instrument can be so adjusted as to become more delicate than a barometer reading to ·001 of an inch. A series of observations are given compared with the density as calculated from an aneroid barometer. The changes indicated by the two instruments are the same in direction but not proportional. G. C. S.

16. *Preservation of the Proto-Sulphate of Iron from Oxydation;* by M. Ruspini, (Journ. de Chim. Med., vol. v.)—The crystals are to be dried in blotting paper, and allowed to effloresce in a drying apparatus at 86° F. The salt may then be kept unchanged in bottles with glass stoppers.

We have seen the same result attained more readily by precipitation with alcohol. G. C. S.

17. *Freezing point of Water lowered by Pressure;* by Prof. W. Thomson, (L., E. and D. Phil. Mag., Aug., 1850.)—Mr. James Thomson the brother of the author has recently shown that the fundamental axiom of Carnot's theory of the motive power of heat, requires as a necessary consequence that the freezing point of water should be lowered by pressure. The result of his calculations gives ·0135 of a degree of Fah. as the depression in temperature for each atmosphere 29·922 inches.

The object of the author was to test the accuracy of these deductions. A suitable thermometer containing ether instead of mercury was inclosed in a glass case and hermetically sealed. Each division of the scale was equal to about $\frac{1}{70}$ of a degree. The experiments were in Oersted's apparatus for the compression of water—the cylinder being filled with ice and water. The column of ether was found to descend immediately upon the application of pressure, and to rise as rapidly when the pressure was withdrawn.

Observation at 8·1 atmosphere gave a depression of 0·106° F.—at 16·8 atm. 0·232° F., differing by —0·003° F. and +0·005° F. from the theoretical depression.

It is worthy of remark that the observations were made without a knowledge of their coincidence with theory. G. C. S.

18. *Test for the Presence of Chloroform in the Human body;* by Dr. Snow, (Lond. Lancet in Chem. Gaz., June, 1850.)—The blood or other parts examined are heated by a chlorid of calcium bath, in a flask to which is attached a tube so bent that the condensed moisture may fall back into the flask, and that a portion of it may be made red-hot. This is connected with another tube terminating in a Woulfe's bottle, both moistened inside with a solution of nitrate of silver. The

chloroform is decomposed in passing the red-hot portion of the tube and the liberated chlorine or hydrochloric acid forms chlorid of silver, which may be tested by dividing the tube with a file, ammonia being tried in one half and nitric acid in the other.

The delicacy of this process may be inferred from the following facts. In undoubted cases of death caused by chloroform, the precipitate appeared as soon as the boiling point was reached. Portions of the muscles of the leg of a child amputated while under the influence of chloroform, gave the precipitate, a few minutes longer being required for its appearance. Two kittens were killed by the inhalation of less than one minim each, the presence of chloroform was detected on six successive days after death, no precautions having been taken to protect the bodies from the air.

It has been ascertained that, at the required temperature,—that of boiling water or a little higher,—no chlorids present in the human body can affect the test. G. C. S.

19. *On the behavior of Cuminic acid in the animal system*; by Dr. Hofmann, (Journ. der Pharm., April, 1850.)—Benzoic and cinnamic acids having been transformed into hippuric acid, in their passage through the body, it seemed desirable to ascertain whether cuminic acid, a homologue of the benzoic, would undergo the same transformation.

Considerable quantities were taken over night by several persons. The urine on evaporation furnished nearly the whole of the cuminic acid unaltered, without a trace of hippuric acid. A repetition of the experiment gave the same result.

Toluylic acid, another homologue, did not reappear in the urine. A very minute quantity of an unknown crystalline neutral substance was obtained. G. C. S.

20. *Action of Essential Oil of Bitter Almond on the Animal System*; by C. G. Mitscherlich, (Buch. Report, iv; Chem. Gaz., Aug., 1850.)—The observations of the author in the main agree with those of Wöhler and Frerichs. The poisonous effects of the crude oil in small doses is due only to the prussic acid it contains.

The pure oil in small doses is oxydated and hippuric acid is found in the urine. In larger doses, one to two drachms, the oxydation is incomplete and the unaltered oil is found in the urine. In such doses it is less poisonous than oil of mustard but more so than the oils of juniper, savine, cinnamon, turpentine, lemons, &c. Its effect on the intestinal canal is similar to that of the above named oils.

When death is produced there is a rapid destruction of sensibility and of voluntary motion, while the accelerated respiration and pulsation still continue. G. C. S.

II. Mineralogy and Geology.

1. *Report of Progress, of the Geological Survey of Canada*, by D. E. Logan, Esq., *Provincial Geologist*. 116 pp. 8vo. *Toronto*, 1850.—During the past year, Mr. Logan has been occupied with investigations about Bay St. Paul and Murray Bay River, on the north side of the St. Lawrence, near longitude 70½° W., and also upon the south side east and west of the Chaudière.

The valley of Bay St. Paul, is the course of the river Gouffre, and Murray Bay River is a few miles to the west. Coal had been reported as occurring in this region, but incorrectly as it was proved, the rocks being the Trenton Limestone, calciferous sandrock, white quartz rock corresponding to the Potsdam Sandstone, and metamorphic rocks as gneiss, either granitic or syenitic. On the uplands, west of St. Urbian Church, the rock is hornblendic and contains large masses of titaniferous iron, one of which was 300 feet long by 90 broad. Among the fossils of the limestone are *Chætetes lycoperdon*, *Streptoplasma corniculum*, *S. crassa*, *Receptaculites neptuni*, *Schizocrinus nudosus*, *Leptæna alternata*, *L. sericea*, *Orthis pectinella*, *Atrypa ambigua*, *Platynotus trentonensis*, *Calymene senaria*, species described by Mr. Hall in his Report on the Trenton limestone fossils of New York.

There are also in the same valleys *tertiary* deposits containing marine shells, among which are *Tellina grænlandica*, *T. calcarea*, *Saxicava rugosa*, and others; and they were traced to a height of 390 feet. At little Malbasic there were six terraces, and in other places, one or more were distinct and corresponded with terraces on the St. Lawrence.

South of the St. Lawrence the observations were of great interest, but we defer citing results till the survey is farther advanced.

On the *Gold of the Chaudière* region Mr. Logan gives some new information.—"The occurrence of gold in the gravel of the valley of the Touffe des Pins, a tributary of the Chaudière, has already been mentioned in a previous Report, and on revisiting the Signiory of Vaudreuil Beauce, a few days were spent in endeavoring to ascertain over what breadth across the stratification, the auriferous gravel might extend. Seven different places were tried, and the metal found in five of them; no attempt was made to determine in what quantity it existed, as without a greater expenditure both of time and money than the funds devoted to the Survey would permit, no such result as might have been considered a just criterion could possibly have been arrived at. We were satisfied to establish the fact of its presence merely, and the smallest particle of the metal was deemed sufficient for the purpose; two of the spots were indicated to us by Mr. Angers as localities in which he had himself met with traces; one of them was on a small brook, tributary to the Rivière à la Famine, entering it on the south side about four or five miles from its mouth. About a mile and a-half above the fall on the Famine, there commences an extensive deposit of clay, sand and gravel; we followed the section made through it by the river for about a mile and a-half, and constantly found the clay beneath and the gravel resting on it; towards the top of the gravel, the bank often presented a horizontal deposit of the mingled oxyds of iron and manganese, in some parts six to eight inches thick, filling the interstices among pebbles of various kinds, many of them being clay and talcose slate, quartz rock, chloritic sandstone, and some of them of white vitreous quartz with grains of black magnetic iron sand in the finer parts. The same deposit with the same arrangement exists on a small brook which gives a section through it at right angles to the main stream, on the S. E. side; ascending this about the third of a mile, and trying a few pounds of the gravel at the top which had not previously been moved, a small particle of the metal was immediately met with. Another locality was about a mile up the stream

which discharges into the Chaudière, opposite the Famine, on the Seignory of Aubert Gallion, being on the twenty-second lot of the domaine, where the metal was first observed by Mr. Fortier, one of the *censitaires*, in a narrow ravine with steep precipices of clay slate on each side; it occurs in the clefts of the slate constituting the bed of the stream, and in the clay and gravel immediately on the top of the rock, mingled with magnetic and chromic iron; the quantity of gravel at the spot is but small in consequence of the narrowness of the ravine, through which the water rushes with great violence during the freshets of spring; about a grain's weight of gold was here obtained; I have since been informed by Mr. Fortier, that he has traced it two miles farther up the stream. The metal was also met with close by the side of the river road, where it is crossed by the brook next below the previous stream. Mr. Hunt found traces of it in the gravel at the foot of the precipice of serpentine, just below the fall of the Guillaume River, where it was associated with grains of magnetic and chromic iron, as well as of rutile and ilmenite. He also discovered it about a mile below the Great Fall on the Bras, in similar gravel lying close on clay slate, where it could not be far removed from the band of serpentine constituting the rock of the fall.

These five localities, as well as that of the Touffe des Pins above mentioned, the Ruisseau Lessard, and the Ruisseau du Lac or du Moulin, in both of which particles have been met with, are all included in an area of about sixty or eighty square miles, with a breadth of about ten miles across the stratification, and I have been informed that traces of the metal have been found on the River Metgermet, flowing into the Rivière du Loup, about fifteen miles still farther to the south-east than the Rivière à la Famine."

The Report of Mr. T. S. Hunt, Chemist and Mineralogist to the Survey, is occupied principally with analyses of soils and mineral springs which may be noticed at length in another number.

2. *On the Gold Mines of Darien, Emigration to New Granada, and Canalization of the Isthmus of Darien;* by Dr. Cullen, (Ath., No. 1189.)—(1.) The Isthmus is a territory of the Republic of New Granada; its most important part, and that which appears naturally best adapted for communication between the Atlantic and Pacific, lies between the Gulf of Darien and the Gulf of San Miguel. Numerous rivers flow into the Bay of Panama on one side, and into the Atlantic on the other; the principal stream is the river Santa Maria, forty miles long, and falling into the Gulf of San Miguel, unobstructed by sand-banks or bars. A few estates are still occupied by the Spanish, but most of the old towns and villages and forts have been long since deserted. About eight miles up the river Santa Maria (or Tuyra) is the village of Chapigana, with a corregidor and about 100 inhabitants, mostly Sambos and Negroes; Mr. Hossack, a Scot, and Don Pepe, a Portuguese, are settled here. A few miles above this village gold occurs abundantly, and about thirty miles above is the town of Yavisa, the capital of the territory and residence of the prefect Don Antonio Baraya. The population is scarcely 100, and the large fort is in good condition, but not garrisoned. The largest vessels can ascend nearly to the Chuquannaqua, a branch of the river Tuyra, a few miles below Yavisa, and up to which the tide extends. This country has been the scene of successful gold-mining

under the Spaniards, and of much buccaneering and futile attempts at colonization on the part of the British, from the days of Sir Francis Drake and Basil Ringrose (1680) to Macgregor (1819.) In the archives of the treasury of Panama is an account of former mining operations at the Mina Real, on the river Cana (a source of the Tuyra), in the Cerro del Espiritu Santo; the royal quinto or 5 per cent. on this mine averaged for a number of years three and a-half millions of dollars per annum, which would give seventy millions per annum for the whole produce; the mining was performed by negroes (never more than three or four hundred) who hewed out the rock, ground it in mortars by means of oxen, and washed it by a stream of water whilst grinding. The mines were closed in 1685 by command of the king of Spain, although in full operation at the time, on account of the numerous incursions of the buccaneers; they have never been re-opened, and the neighboring mountains, though rich in gold, have never been worked. Dr. Cullen found the soil on the banks of the streams very fertile, and himself collected 3lbs. of gold at various spots, and several pieces of quartz-rock with veins of gold in it. As an agricultural country, Darien presents the most favorable prospects; its fertile soil, and the rapid growth of the plantain sugar-cane which arrives at maturity in nine months, make it superior to Demerara, and, though abounding in rivers, it is free from swamps and land liable to inundation; the timber is equal to British Guiana, and game (including alligators and "tigers") is abundant.

(2.) The government of New Granada affords great advantages to immigrants in the form of employment, loans and grants of land; the average passage to Carthagena or S. Martha is thirty days, and emigrants can go out for £6 per head. The tracts to be colonized consist of high table-lands and elevated valleys (nearly 9,000 feet), with a temperate climate (50° to 80°) all the year. On the table-lands wheat will grow, and in the valleys coffee, cotton, cocoa, sugar-cane, and other tropical crops. The settler has his choice of climate, from the level of tropical vegetation to regions of perpetual snow; the country is scattered over with towns affording supplies, and means of internal and external communication. The population consists of old Creole Spaniards, and the religion is Roman Catholic, but perfect liberty is allowed; the government is a pure democracy. The population of the capital, Bogota, is 60,000. The Cordilleras form a great table-land or platform, on which are piled numerous mountains intersected by valleys in every direction.

(3.) In conclusion, the writer recommends the rivers Chuquanaqua and Savana as the most direct and feasible mode of communication with the Atlantic; the Savana is navigable by large vessels for ten miles, above which for fifteen miles it would require deepening, and then there remain only ten miles to the Atlantic, where the cutting would be assisted by a ravine. From a mountain on the river Lara, a branch of the Savana, both Atlantic and Pacific were visible. The canal would open near the old Scotch settlement of New Edinburgh at Punto Escoces.

3. *On the Glacial Phenomena of the Neighborhood of Edinburgh, with some Remarks on the General Subject;* by Mr. R. CHAMBERS, (Athenæum, No. 1189.)—The author compares the glacial phenomena of Scotland with those of Sweden, with this difference, that in Scotland much of the surface has been masked, and many of the glacial mask-

ings obliterated since the glacial epoch. The trap districts near Edinburgh often form long and narrow hills, running east-north-east, some of them 800 feet high, and several of them presenting cliffs to the west, and long gentle declivities on the east. Mr. Chambers described the Costorphine Hill as a stratum of trap dipping to the west, and with a cliff in a line north and south. In its crest, which rises to 470 feet above the sea, are three or four transverse clefts. On the west surface of the hill, the rock, wherever it is exposed, is found to be rounded (*moutonnée*), smoothed, and grooved. The grooves, and the clefts in the crest of the hill, all lie in one direction, viz., directed to a point to the north of east. There are also, to the east of the hill, long hollows, with rounded intervening swells; and these run in precisely the same direction. At various places between the hill and the sea are seen sandstone surfaces, worn down to a remarkable flatness and smoothness, and in several instances marked with striæ, all pointing in the same direction. In Edinburgh itself, the north side of the Castle rock is smoothed and horizontally grooved, as if by ice passing along the hollow below. In forming the Queen's drive, on the south side of Arthur's Seat, the surface of the rock in the hollow between that hill and "Sampson's Ribs," was found to be wholly smoothed, polished and furrowed and striated in the direction of the passage, which is easterly; on the north side of the same hill, the railway works have also laid bare a prominent mass of rock, polished and striated on its upper and western sides; other rounded and polished rocks occur up to a height of 400 feet. Throughout the Valley of the Forth, from the Pentlands on one side to the Fife hills on the other, from Linlithgow to Dunbar, the sandstone surfaces, wherever they come up, are likewise smoothed, and in many instances striated in an east-north-east direction. The trap hills rising in this valley are all long and narrow, generally free from abruptness on the sides, often abraded on the west, and generally sloping away gently to the east; the direction here also is always to E.N.E. Surfaces on the Pentlands and in Fife exhibit striation precisely conformable. In short, if a deep ice-flow passed through this valley, it might be expected to produce precisely the phenomena which have been observed. The similar markings in other districts of Scotland were shown for the most part, though not without striking exceptions, to be directed towards the east and south. Mr. Chambers adverted to the theory of debacles which was started to account for the appearances, as now nearly given up. Ice was generally acknowledged as concerned in producing them, because the appearances were precisely those which existing glaciers produce. But there was great room for speculation as to the circumstances under which the presumed glacial agent was applied. Mr. Chambers declined theorizing on the subject, but pointed out various conditions which any theory on the subject must explain. (1.) How ice could move over so large a portion of the North American continent, in a direction admitted to be tolerably uniform, allowing for slight deviations, easily explicable, as owing to inequalities in the original surface, and this without any mountain chain to give it forth. (2.) How this ice was capable of ascending slopes and topping mountains of considerable height. (3.) How, in such a valley as that of the Forth, there could be an ice-torrent of undeviating flow for many miles, and deep enough to envelope hills many hundred feet high.

4. *On Labradorite from the Island of Maui, Hawaiian Group;* by J. D. DANA.—The labradorite of Maui occurs within the large crater of Haleakala, and is in small glassy tabular crystals, nearly or quite transparent. The angle obtained between P and the cleavage plane was 86° 45′. There are no distinct lateral faces upon the crystals seen. According to an analysis by Mr. Adolph Schlieper,* the composition is

Si	Al	Fe	Ca	Mg	Na	K
53·98	27·56	1·14	8·65	1·35	6·06	0·47=99·21
Oxygen 28·02	12·87	0·34	2·47	0·52	1·55	0·08

which corresponds to the formula of labradorite, and gives the special formula $(\frac{2}{3}\dot{C}a+\frac{1}{3}\dot{N}a)\,\ddot{S}i+\ddot{A}l\,\ddot{S}i$. In a second incomplete analysis, Mr. Schlieper obtained

Si	Al, Fe	Ca
53·88	28·40	8·87

This last result was obtained from specimens procured by the writer at the Hawaiian Islands, and it removes a doubt with regard to the locality of the other crystals, expressed in his Mineralogy, p. 686. This species is mentioned in the writer's Geological Report of the Pacific, &c., p. 230, where an imperfect analysis by Prof. Silliman, Jr. is given, made on less than a gramme of the mineral.

5. *Gibbsite.*—Prof. Silliman, Jr., has made a reëxamination of this mineral from Richmond Mass. for phosphoric acid by means of molybdate of ammonia, and has confirmed his former trial that it contains no phosphoric acid. This is true therefore of all the specimens he has examined, and must be generally true, if not universally, of all the specimens from that locality.

III. ZOOLOGY.

1. *On the order of Succession of Parts in Foraminiferæ;* by L. F. DE POURTALES.—(Proceedings of the American Association for the Advancement of Science, third meeting, held at Charleston, S. C., March, 1850, p. 89.)—Since the identity of the fundamental structure of animals and plants has been ascertained by Lehman, various attempts have been made to trace an analogy between the growth of the various types in the two kingdoms. These attempts have failed, in as far as the analogy has been found very loose, and the strong contrast which exists between them has been more fully brought out, rather than an agreement.

Mr. Pourtales has, for the first time, pointed out a direct, well-sustained analogy, which is to be found in the order of succession of the cells in foraminiferæ of the genera *Textularia*, *Candima*, *Biloculina*, *Triloculina* and *Quinqueloculina.* This succession agrees fully with the succession of leaves in plants—so fully that it can be expressed by the same fractions with which botanists are now in the habit of expressing phyllotaxis in the vegetable kingdom. This is, therefore, an important additional link in the investigation of the plan which regulates the normal position of parts in organized beings—a link which may lead to include in one universal formula the rhythmic movements

* See Dana's Mineralogy, p. 686.

which preside over the development of all finite beings, as the phyllotactic formulæ themselves are now known to express also the natural relations which exist in the movements of the bodies belonging to our solar system.

2. *On the Principles of Classification;* by L. Agassiz, (Ib.)—It may be said that investigations upon the structure of animals have already yielded all the information coming from this source which can serve to improve our classification of the animal kingdom.

After the great natural divisions of the animal kingdom have been circumscribed in accordance with their anatomical structure, after the classes of the animal kingdom have been characterized by organic differences, it is hardly possible to expect that further investigations upon the structure of animals will afford the means of establishing correctly the natural relations of the families. For it is already seen that the amount of organic difference which exists between the different families is either too insignificant to afford a test by which to settle their preëminence or inferiority, or so striking as to impress us with an *exaggerated* idea of their difference. Many examples could be quoted to show, that, in this respect, from the same identical facts, naturalists have arrived at very opposite conclusions. And this diversity of opinion among investigators of equal ability leads me to think that comparative anatomy has done its work in that direction, and that we must seek for another principle in order to settle in a natural way the respective positions of the minor divisions throughout the animal kingdom, and to set aside, once forever, the arbitrary decisions which we are constantly tempted to introduce into our classifications, whenever we attempt to arrange all the families in natural groups. Before so much had been done to improve the natural classification of the animal kingdom, it was hardly possible to notice how much was, on every occasion, settled by induction, and even arbitrary decision, beyond what the knowledge of facts would justify—for the brilliant results which the introduction of comparative anatomy, as the foundation of the classification of the animal kingdom, has brought to light, must naturally have blinded us to the imperfections and deficiencies which constantly accompany the most important improvements in the natural arrangement of every class. Nevertheless, our confidence in the possibility of ascertaining the natural relations of all animals has been increased by the growing agreement between the different systems; and there is no philosophical observer who has not noticed this process of gradual approximation towards a greater uniformity in the view taken by different observers of the natural affinities of animals, however concealed this agreement has often been in consequence of changes of name or transposition of the order in which the objects were introduced.

The time has, however, gone by when the mere translation of family names, or of more general or minor divisions, into another language, could be presented as a new system, and the raising of a secondary division into the rank of a primary group, or the lowering of a primary division into a subordinate position, constituted an improvement in the knowledge of the natural relations of animals. Nothing short of a material addition to the information we possess respecting any group of animals, can now be considered as a real advance in zoology.

It should be further considered that our object is not merely or chiefly to ascertain the structural relations of animals, but to know all the various relations which have been established between them, and which they sustain toward the world in which they live. The knowledge of the natural embryonic development—of the order of succession in geological times—of the geographical distribution upon the surface of our globe—and of the habits arising from their natural relations to the elements in which they live—all these considerations are of as great importance in our zoological studies as the knowledge of the structure and functions of their organs, to which, of late, more exclusive attention has been paid.

When comparing, in former years, the characters of fossil fishes, especially with a view of ascertaining their natural relations to the living types, I was struck with the fact that those of earlier ages presented many structural peculiarities, which occur only in the embryonic condition of the fishes of our days, and also that the older representatives of any family rank lower in comparison to their living representatives.

This led me to infer that embryonic data might be applied with advantage to the correct appreciation of the natural relations of the various members of one and the same family, and perhaps also to the determination of the relative position of closely allied types.

Under this impression, I began to compare young animals of various families with the different types of the same family in their full grown condition, when I was forcibly struck with the close resemblance there is between the younger stages of development of such representatives as could otherwise be recognized as ranking high in their respective families, and the lower forms belonging to the same groups. This led naturally to the conclusion that the change which animals undergo during their growth might safely be taken as a standard to determine the natural order of succession of all the representatives of any given type within the limits in which the higher ones pass successively through transient forms which the lower ones naturally present permanently in their full grown condition.

This principle, once ascertained, led to the result, upon more extensive investigations, that a complete knowledge of the metamorphoses of animals, from the earliest period of their embryonic development to the last change they undergo before reaching their mature condition, would afford, throughout the animal kingdom, a true measure by which to ascertain precisely, and without arbitrary decision on our own part, the natural relative position of all the minor groups of the animal kingdom.

Beginning the revision of the animal kingdom with the type of the Articulata, it was not difficult, with these views, to ascertain that the Worms, as a natural type, rank lowest in this department, as they represent permanently a structural adaptation which is closely analogous to the earliest condition of development of the insects; that the Crustacea constitute a class intermediate between the worms and insects, and not superior to the insects, as some naturalists would have them; inasmuch as the highest combination of their rings presents us with an arrangement similar to that of the pupa of insects, in which the joints of the head and of the chest are combined in an immovable shield, as in the

pupa of insects, and in which the joints of the abdomen alone remain movable, is also the case among the highest Crustacea. The position of the insects as the highest class, can no longer be denied, when we consider that in them the body is at last divided into three distinct regions—head, chest and abdomen—and that the locomotive appendages, which, in the lower classes, are so numerous and uniform along the whole length of the body, are reduced to the region of the chest, and assume there a particular development.

Again, the transformation of the respiratory organs is an additional evidence in favor of such an arrangement, as will be admitted from the fact that Worms and Crustacea have chiefly a branchial respiration, while in insects it becomes aërial, at least in their perfect condition.

Once upon this track, it was easy to follow out the minor changes which these animals undergo during their final transformation, and to derive from the knowledge of these changes sufficient information to assign a definite position to all the subordinate groups in each of these classes. Taking the insects, for instance, into special consideration, we ascertain readily that chewing insects rank below the sucking tribes, as their larvæ are chewing worms, provided with powerful jaws, even in the case of those which, like Lepidoptera, have the most perfectly developed sucking apparatus in their mature condition.

Again, an investigation of the changes which the wings undergo in their formation, and the manner in which they are unfolded, when the perfect insect is hatched, led to the discovery that Coleopterous Insects, far from ranking high, must be considered as lowest among insects, inasmuch as the upper larval wings of Lepidoptera are a sort of elytra, which, after being cast in the last moulting, are succeeded by the more perfect membranous wing, which in its turn, undergoes such a development as to assign to those Lepidoptera, which have their wings folded backwards and enclosing the body, a position below those in which the wings spread sideways; and the highest position to those which raise their wings upwards. So that these investigations have settled even the relative position of the secondary minor groups in each of these orders, and though, as yet, imperfectly traced out, they have at least shown the principle upon which a natural classification of these animals might be carried into the most minute details, without ever leaving any point to arbitrary decision. Similar results have already been arrived at in other classes; as, for instance, among Medusæ, where naked-eyed Discophori, with alternate generations, must be considered as the lowest type, recalling, in one of their conditions, the appearance of the inferior class of polypi; when the covered-eyed Discophori, with their strobiloid generation, begins in its lowest state with a medusoid polyp.

Similar facts are known among Echinoderms, in which, among Crinoids, the highest free forms begin with germs provided with a stem, thus assigning, on embryological grounds, a lower position to all those which are provided with a stem.

In the same manner has it been possible to determine the position of Bryozoa among Mollusca below Ascidiæ, upon the ground that their embryonic development is similar. It has been possible, in the same way to assign to Pteropoda a position inferior to that of Gasteropoda proper, and not intermediate between Gasteropoda and Cephalopoda,

as anatomical investigations would seem to indicate. For it is now plain that the spreading appendages of the body of Pteropoda are not analogous to the long tentacles which encircle the head in cuttle-fishes, but correspond to the vibratory rudders of the embryo in marine Gasteropoda.

Again, the position of Foraminiferæ, seems to me no longer doubtful. They are neither microscopic Cephalopoda, nor Polypi, as of late it has been generally thought best to consider them, but constitute a truly embryonic type in the great division of Gasteropoda, exemplifying, in this natural division, in a permanent condition, the embryonic state of development of common Gasteropoda, during which the bulk of the yolk passes through the process of repeated divisions.

This principle—of embryological changes as a foundation of the natural classification in the internal arrangement of all the minor groups in the natural classes of the animal kingdom—applies with equal success to the Vertebrata.

We need only contrast the successive changes of tailless Batrachians during their metamorphoses, with the permanent forms of the caudate and branchiate types in that order, to be satisfied that the relative rank of all these genera can in no way be better determined, than by a direct comparison of the permanent forms of the whole group, with the successive changes in the embryonic condition of its higher types; and a comparison of the metamorphoses themselves, in the different genera, will leave no doubt as to which of them the highest rank should be assigned.

I have already, on other occasions, alluded to the improvements which are likely to be introduced into our classification of birds, upon considerations derived from embryological data. I may be permitted here to add, that even the classification of mammalia will receive decided improvements upon the consideration of their embryological changes. A single instance, even now, will at least show that the true relative rank of their families can be determined in that way. We need only compare, among true Carnivora, the Plantigrades, the Digitigrades, and the web-footed Seals, with the transformation of the limbs in the embryo of cats and dogs, to be satisfied that the order in which these animals are arranged by Cuvier, does not agree with their natural metamorphoses, and that the Plantigrades should rank below the Digitigrades, nearer to the Seals, and the Digitigrades highest; and the affinity of the Ice-Bear to the Seals will further sustain this statement.

These remarks will, at the same time, show that no investigations are at present more needed to improve our natural methods in classification, than a thorough study of young animals; and that an extensive illustration of the young of all the principal representatives of the great natural groups in the animal kingdom, would, for the present, contribute more to the advance of Zoology, than any amount of description of new species.

But these investigations of young animals should be made with a full knowledge of their various relations, and with the view of ascertaining chiefly those zoological peculiarities, which may illustrate more fully the value of all these relations.

There is another field of investigation hardly yet entered upon, which is likely to contribute largely to the improvement of our classification. I refer to the study of fossils, compared in their structural peculiarities with the embryos of their living representatives. It has already been shown that many fossils of the earliest geological periods have a close resemblance to embryonic forms of the present day; and that, in their respective families, these fossils rank among the lower types.

This result, in itself, should be a sufficient inducement to trace this double relation, and to ascertain from as many fossils as possible, whenever they are sufficiently well preserved to allow of such comparisons, what is the extent of their analogy to embryonic forms of the present period, and also what is the amount of affinity they have to the lower types of their respective classes.

I would mention, in this connection, the necessity of a revised comparison of the Trilobites, with the earliest stages of development of Crustacea, when it will be found, as I have already seen it, that almost all the genera of Trilobites seem to be the prophetic images, in a gigantic form, of the different types the Crustacea present in their embryonic state. The different degees of development of these different types, when contrasted with each other, will go far to assign to each genus, its appropriate rank. I venture even to say, that the time will come when the relative age of fossils, within certain limits, will be as satisfactory a guide in assigning them their normal position in a natural system, as the facts derived from the study of their structure,—so intimate are the connections existing between all parts of the wonderful plan displayed in creation.

Little or no advantage has as yet been derived from the study of the relations of animals with the elements in which they live, in ascertaining their natural relations among themselves; but even in this respect we may derive valuable hints from a careful study of the geographical distribution of all animals; and the mere nature of the elements in which they live naturally.

On reviewing lately the whole animal kingdom, with a view to ascertain what is the value of the natural connection between the animals and the media in which they live, with reference to organic gradation, I have satisfied myself that aquatic types are decidedly inferior to the terrestrial; the marine inferior to the lacustrine and fluviatile ones; that those which live upon the main land and burrow under ground are inferior to those which live above ground; that nocturnal types are inferior to diurnal types; and that under otherwise similar circumstances, representatives of one and the same group which differ in these respects, have a higher and lower rank, in accordance with their external circumstances; so much so, that where we have no other guide, an inference respecting their natural position may be fairly derived from their conditions of life.

It will thus be obvious that as soon as we introduce simultaneously into our classification considerations derived from all these different sources; as soon as we allow the embryonic development, geological succession, geographical distribution, and relation to the natural elements, to assist us in our efforts to assign to all animals a natural position in one great system, we shall be able to sketch a far more complete

picture of the great diversity which exists in nature, than if we allow ourselves to be guided chiefly by anatomical data; and my object at present is mainly to urge the necessity of studies in these different directions, with a view of improving our classification, and to insist upon the necessity of keeping in view, at the same time, all these facts, whenever we attempt to form a correct idea of the manifested relations which exist throughout the creation, as to all their different types, from the earliest period of the existence of animals up to the present day.

3. *Observations on the Blind Fish of the Mammoth Cave*; by L. Agassiz. (In reply to a letter of enquiry from the Senior Editor.)—The blind fish of the Mammoth Cave, was for the first time described in 1842, in the Zoology of New York, by Dr. Dekay, Part 3d, page 187, under the name of "Amblyopsis spelæus," and referred, with doubt, to the family of "Siluridæ," on account of a remote resemblance to my genus Cetopsis. Dr. J. Wyman has published a more minute description of it, with very interesting anatomical details, in vol. xlv, of the American Journal of Science and Arts, 1843, page 94.

In 1844, Dr. Tellkampf published a more extended description, with figures, in "Müller's Archiv," for 1844, and mentioned several other animals, found also in the cave, among which the most interesting is—a Crustacean, which he calls, "Astacus pellucidus," already mentioned, but not described by Mr. Thompson, President of the Natural History Society of Belfast. Both Thompson and Tellkampf speak of eyes, in this species; but they are mistaken. I have examined several specimens, and satisfied myself, that the peduncle of the eye only, exists, but there are no visible facets at its extremity, as in other crawfish.

Mr. Thompson mentions farther crickets, allied to "Phalangopsis longipes," of which Tellkampf says that it occurs throughout the cave. Of Spiders, Dr. Tellkampf, found two eyeless small, white species, which he calls "Phalangodes armata" and "Anthrobia monmouthia"—flies, of the genus "Anthomyia"—a minute shrimp, called by him "Triura cavernicola," and two blind beetles—"Anophthalmus Tellkampfii," of Erichson, and "Adelops hirtus;" of most of which Dr. Tellkampf has published a full description and figures, in a subsequent paper, inserted in Erichson's Archiv, 1844, page 318.

The infusoria observed in the cave resemble "Monas kolpoda," "Monas socialis" and "Bodo intestinalis"—a new Chilomonas, which he calls "Ch. emarginata," and a species, allied to "Kolpoda cucullus."

As already mentioned, Dekay has referred the blind fish, with doubt, to the family of Siluridæ. Dr. Tellkampf however establishes for it a distinct family. Dr. Storer, in his Synopsis of the fishes of North America, published in 1846, in the Memoirs of the American Academy of Arts and Sciences, is also of opinion that it should constitute a distinct family, to which he gives the new name of "Hypsæidæ," page 435. From the circumstance of its being viviparous, from the character of its scales, and from the form and structure of its head, I am inclined to consider this fish rather as an aberrant type of my family of Cyprinodonts.

You ask me to give my opinion, respecting the primitive state of the eyeless animals of the Mammoth Cave. This is one of the most important questions to settle in Natural History, and I have several years

portant questions to settle in Natural History, and I have several years ago, proposed a plan for its investigation, which, if well conducted, would lead to as important results, as any series of investigations, which can be conceived, for it might settle, once for ever, the question, in what condition and where the animals now living on the earth, were first called into existence. But the investigation would involve such long and laborious researches, that I doubt whether it will ever be undertaken. It has occurred to me, that the final step would be a thorough anatomical study of the species found in the cave, with extensive comparison of allied species, found elsewhere—next, an investigation of the embryology of all of them, and when fully prepared by such researches, an attempt to raise embryos, of the species found in the cave, under various circumstances, different from those, in which they are naturally found at present.

If physical circumstances ever modified organized beings, it should be easily ascertained here. For my own part, however, I think that the blind animals of the cave would only show organs of vision during their embryonic state, in conformity with the normal development of the respective types to which they belong, and that even when placed under a moderate influence of light, incapable of injuring them, but sufficient to favor the growth of their eyes in the allied species provided with them, the young of those species peculiar to the cave would gradually grow blind, while the others would acquire perfect eyes; for I am convinced, from all I know of the geographical distribution of animals, that they were created under the circumstances in which they now live, within the limits over which they range, and with the structural peculiarities which characterize them, at the present day. But this is a mere inference, and whoever would settle the question by direct experiment, might be sure to earn the everlasting gratitude of men of science. And here is a great aim for the young American naturalist who would not shrink from the idea of devoting his life to the solution of one great question.

4. *On the Carcinological Collections of the United States;* by Prof. Lewis R. Gibbes, (Proc. Amer. Assoc., 3d meeting held at Charleston, S. C., March, 1850.)—This catalogue of the species of Crustacea in the principal collections in this country (exclusive of that of the Exploring Expedition at Washington) is enriched with many valuable notes, by the author, and descriptions of several new species. The names of the new species are as follows:—*Hayas aculeata*, from Key West, *Cryptopodia granulata*, from Charleston Harbor, *Carpilius viridus*, from the Sandwich Islands, *Carpilius prætermissus*, E. Indies, *Chlorodius Floridanus*, from Key West, *Panopæus Wurdemannii*, from Enterprise, Florida, *Lupa Sayi*, (Lupa pelagica of *Say*,) *Grapsus transversus*, from Key West, *Hepatus decorus*, Charleston Harbor, *Ilia armata*, *Porcellana ocellata*, coast of S. Carolina, *P. armata*, from Florida, *P. sexspinosa*, from Key West, *P. magnifica*, from Vera Cruz, *P. macrocheles*, coast of S. Carolina, *Ibacus novemdentatus*, *Callianassa grandimana*, from Key West, *Alpheus formosus*, from Key West, *Pontonia domestica*, coast of S. Carolina, *Hippolyte Wurdemanni*, from Key West, *H. paludosa*, fresh-water ponds, S. Carolina, *Squilla neglecta*, Charleston Harbor.

5. *Observations on the Fishes of Nova Scotia and Labrador*; by H. R. Storer, 24 pp. 8vo, (from the Bost. Jour. Nat. Hist., October, 1850.)—This valuable paper contains descriptions of the following species:—*Acanthocottus Labradoricus*, Girard, *A. patris*, H. R. Storer (figure 2 plate 7), *A. ocellatus*, H. R. Storer, *Gasterosteus Cuvieri*, Girard (figure 1 plate 7), *Gunnellus ingens*, H. R. Storer (figure 1 plate 8), *Salmo immaculatus*, H. R. Storer, *Platessa rostrata*, H. R. Storer (figure on plate 8.) There are also critical remarks and notices of many other species.

IV. Astronomy.

1. *The new Planet Parthenope.*—The small planet discovered by M. Gasparis of Naples, May 11, 1850, and denominated *Parthenope*, belongs to the group between Mars and Jupiter. The following elements of its orbit are furnished by Luther.

Epoch, 1850, May	25·0 m. t. Berlin.	
Mean longitude,	288° 40′ 43″·27	
Long. of perihelion,	316 49 51 ·82	m. Eqx. Jan. 0, 1850.
" " asc. node,	124 57 55 ·78	
Inclination,	4 36 56 ·75	
Angle of excentricity,	5 42 30 ·35	
Log. semi axis major,	0·3893138	
Mean daily motion,	924″·7747	
Sidereal period,	1401 days.	

2. *The new Planet Clio.*—Mr. Hind, of London, who discovered this planet September 13, 1850, first proposed to designate it by the name *Victoria*, but objections being made to this, he has consented to substitute the name *Clio*, which denomination will probably be adopted.

Several sets of the elements of the orbit of the new planet have been computed and published, from among which we select the one by Mr. Ferguson, of the Washington Observatory, given in No. 19 of Gould's Astronomical Journal. It is based on the observations of September 13, 21 and 30.

1850, Sept. 13, mean time Greenwich.

Mean Longitude,	32° 48′ 29″·2
Long. of Asc. Node,	236 49 43
" " perihelion,	302 55, 1 ·5
Inclination,	8 3 38 ·5
Angle of excentricity,	14 15 27 ·4
Log. semi axis major,	0·3729403
Mean daily motion,	978″·5796

3. *Another new Planet.*—M. Gasparis, at Naples in Italy, discovered, on the 2d of November, 1850, a new planet, resembling a star of the 9th or 10th magnitude. Its place Nov. 2, 7h. 3m. 6s·5 m. t. Naples, was R. A. 30° 31′ 49″·9 and N. decl. 7° 58′ 55″. The R. A. was diminishing, and the N. declination increasing.

4. *Petersen's Comet.*—On the 1st of May, 1850, Dr. Petersen, at the Altona Observatory, discovered a telescopic comet in the constellation *Draco*. D'Arrest has calculated the following elements, viz.

Time of perihelion passage, 1850, July, 23·48002 Berl. m. t.				
Long. of perihelion,	273°	23′	47″·84	M. eqx. 1850·0
" " asc. node, .	92	53	23 ·30	
Inclination, . .	68	10	36 ·93	
Log. per. dist. . .	0·0339176			
Motion,	direct.			

5. *Bond's Comet.*—On the 29th of August, 1850, Mr. Geo. P. Bond, of the Cambridge Observatory, discovered a faint telescopic comet in the constellation *Camelopardus*. It was subsequently discovered by four independent observers. The following elements of its orbit by Mr. T. H. Safford, Jr., (Astr. Jour., No. 16,) are based on the Cambridge observations of Aug. 29, Sept. 3 and Sept. 8.

Time of perihelion passage, 1850, Oct. 19·3133 Gr. m. t.			
Log. of perihelion distance, .	9·751524		
Long. of perihelion, . .	89°	20′	17″
" " asc. node, . .	205	55	47
Inclination, ...	40	10	52

6. *Shooting Stars of August* 10, 1850.—Throughout the evening of Thursday, Aug. 8, 1850, the sky was quite hazy, and at dawn of the next day was found entirely overcast. The night of Friday, the 9th, was clear, and observations for the expected meteors were made by Messrs. J. L. Blodget, M. C. Weld and myself. During two hours and twenty minutes we noted *four hundred and fifty-one* different shooting stars as follows, viz.

	N. E.	S.	N. W.		
from 0h. 40m. to. 1 A.M.	15	28	12	=	55
" 1 2	40	107	69	=	216
" 2 3	43	78	59	=	180

Of these many were very brilliant, and the majority moved in paths which, traced back, would intersect in the vicinity of the constellation Perseus.

The night of Saturday, the 10th, was also clear. From 10^h to 12^h P. M., Messrs. Bradley, Blodget and Root observed *three hundred and twelve* different shooting stars, as follows, viz.

	N.	S.	W.		
10h.—11h.	48	80	45	=	173
11h.—12h.	55	36	48	=	139

From midnight to 3 A.M., Messrs. Wm. Hillhouse and H. W. Brinsmade observed *three hundred and fifty-one* different shooting stars, although many were lost by an intermission of about an hour on the part of one of the observers.

The foregoing facts show that the usual meteoric period of August was fully sustained the present year.

It may be worthy of mention that a slight display of the Aurora Borealis was seen here during most of the night of the 9th, and again on the night of the 10th.

E. C. Herrick.

7. *Meteoric Observations in November and December*, 1850.—For many years past the meteoric visitation of November 13th has failed, and the present year must probably be added to the number.

The morning of November 11th, 1850, was clear, and at 5 A.M. I watched for five minutes and saw only two meteors. The next morning was overcast. The morning of the 13th was nearly clear, and during a watch of about fifteen minutes I saw only three or four meteors.

In December, 1850, the evenings of the 5th, 6th and 7th were overcast and rainy. The sky became clear about 10 P.M. of the 7th, and two persons who were abroad between that time and midnight report that shooting stars were unusually frequent, but they made no definite observations. I watched a few minutes about 7 P.M. of the 8th, and again about 5 A. M. of the 9th, but saw nothing uncommon. E. C. H.

8. *Meteor seen in full Daylight.*—On Sunday, June 16th, 1850, a brilliant fire ball was seen in the northern sky, by two observers in New Haven, while the sun was shining in full strength, about an hour before its setting. The time was $6^h\ 25^m$; the sky clear.

The meteor was of a brilliant white, apparently as large as Venus, with a train about a degree long, and disappeared without apparent explosion. Its motion was slow, the time of flight being about two seconds. Mr. George Rice and Mr. J. P. Humaston, who were sitting together at the time, each saw the body independently. Their separate testimony gave its position as follows, viz., when first detected, N. 11° or 14° E., and altitude 27° or 35°; at disappearance, N. 14° or 11° W. and altitude 16°.

The meteor must have been of extraordinary brilliancy to have made itself visible in such circumstances, and had it occurred in the night season would, no doubt, have been a grand spectacle. If any person elsewhere saw the phenomenon, it is to be hoped they will publish their observations, in order to furnish the means for determining the magnitude, velocity and direction of the body. E. C. H.

9. *Meteor of September* 30, 1850.—On Monday evening, Sept. 30, 1850, about 8 o'clock, a meteoric fire ball of uncommon splendor was seen throughout New England and the adjoining regions. To an observer in Boston, it appeared to originate near the sword-handle of Perseus, and to move southerly descending to a point about three degrees below alpha Arietis, where it exploded, with a very brilliant flash.

An interesting account of this phenomenon has been published in the Daily Evening Traveller of Boston, Oct. 21, by W. C. Bond, Esq., Director of the Cambridge Observatory, accompanied by six figures, representing the phases assumed by the train remaining after the explosion of the meteor. From Mr. Bond's description we derive the following particulars.

"The meteor exploded leaving a bright train about eight degrees long, extending from near the *Head of Medusa* towards a point three degrees below the star *alpha Arietis*, this being the direction of motion, and projecting a portion of its mass forward about two degrees. This took place at $8^h\ 54^m$ m. s. t. of the Observatory, and in or very near the small constellation *Musca Borealis*, in R. A. $2^h\ 30^m$ and N. decl. 27°. There were numerous radiations, but nothing sparkling in its appearance. At $8^h\ 57^m$ this had subsided into a serpentine figure about half a degree broad in the widest part and ten degrees long. At 9^h

the preceding portion had extended upward, or, as expressed by one observer, 'it appeared to draw up its head like a serpent.' At $9^h\ 3^m$ the preceding portion had curved quite around.

"During these changes the meteor had continued a bright, conspicuous object, some ten degrees in length, lying nearly horizontal. It was examined with three different telescopes--the comet-seeker, the four-feet refractor, and the great Equatorial. The appearance was that of a congregation of minute bright clouds, of the formation usually denominated *cirrocumuli*."

At $9^h\ 7^m$ it had assumed a figure resembling the appearance of Halley's comet as seen by Sir John Herschel, at the Cape of Good Hope, January 28, 1836.

"The meteor now commenced a slow, regular motion, passing about a degree below the star *alpha Arietis*, towards a point somewhat above the planet Saturn, at the same time rotating apparently on a point answering to the nucleus of the explosion, and expanding in every direction."

At $9^h\ 28^m$ its external outline touched the planet Saturn. The body "was now extended in breadth to twelve degrees, its longest diameter reaching upwards nearly to the zenith. Its rotatory motion had therefore been equal to an angle of about ninety degrees in twenty minutes of time. Although it had now become a faint nebulous light, yet it continued to exhibit a well defined boundary until past ten o'clock, having been under observation *more than an hour*."

"From observations communicated by Hon. Wm. Mitchell, of Nantucket, combined with our own, we have ascertained that the vertical height of this meteor above the surface of the earth was about fifty miles, and its distance from Cambridge one hundred miles in a northeast direction."

We subjoin an account of the same phenomenon as seen by Mr. J. C. Hoadley.

"On leaving Springfield this evening, (Sept. 30th, 1850,) in the cars, at $8^h\ 51^m$, (Boston time) for Worcester, I opened the window for the purpose of casting a glance at Algol, when my attention was arrested by a bright ball of fire, of a bluish color, moving rapidly in a horizontal direction, from east to west, leaving a straight, clear line of yellowish light, and exploding with violet corruscations. My instantaneous impression was that it was a piece of artificial fire-works, like a flying pigeon, quite near, and perhaps twenty feet from the ground; but a moment's observation showed that it suffered no parallax from our rapid and increasing motion, and revealed it to be a meteor. It was then $8^h\ 53^m$, and the moment of extinction could not have been half a minute earlier.

The train of light seemed to remain equally distinct, straight and thread-like, for four minutes, and occupied the same apparent position in the heavens, viz.: from the Pleiades, westerly about twenty-five degrees, to the head of Cetus, parallel to the horizon, and elevated from it about twenty degrees, these angles being measured approximately with a pocket rule as a sector.

At $8^h\ 57^m$ the line of light began to curve upward near the west end, as though that part were wafted upward by a current of air; and at

9^h 0^n the whole had moved towards the zenith relatively to the stars, about two degrees, still remaining straight from the east end to beyond the center, and thence convex upward to the west end, but growing broader and more diffusive. Its breadth at this time was about ten minutes, and its soft yellowish lustre fully equal to that of the planet Saturn shining near it in Pisces.

It continued to rise slowly, and to grow broader and more diffusive, until, at 9^h 18^m it could be just discerned as a faint light cloud in the lower part of Aries, about 8^c above its first position, and occupying nearly the same place in azimuth.

During all this time we were in rapid motion, nearly in the direction of the meteor, and reached at 9^h 20^m the village of Palmer, sixteen miles from Springfield. No sound was heard at the explosion, or subsequently. A few other meteors were noticed during the evening, but only in usual numbers, and of ordinary appearance.

The preceding observations were noted at the time, with a pencil, and the times corrected on reaching Worcester, to Boston time.

Worcester, Mass.

10. *Periodical Meteors of August*, 1848 *and* 1849; by C. B. Forshey, (communicated for this Journal.)—1848.—For several years past I have been inclined to believe that the display of meteors usually seen on the 9th and 10th of August, commenced much earlier in the month.

For the purpose of determining this question, I observed from about the 20th of July, 1848. On the evening of the 26th, I was first rewarded by the appearance of several meteors which followed the proper direction, and had the usual characteristics of the August display. Again on the 29th I observed about one hour, and saw six meteors whose paths traced backward, passed near above the head of Perseus.

Again on the night of the 2nd of August, two observers with a good view, saw only four meteors of this description, from 9 till 10 P. M. In one hour after, I saw four meteors, with a view of about one-twentieth of the heavens. During the whole evening only four meteors were seen, not conformable to the radiant in Perseus.

From my position I could not be very sure of the *point* of intersection of the paths in all those regarded as conformable from their general appearance; but two I am sure would pass between the sword cluster and the head of Perseus, both moving horizontally.

August 3rd.—With Dr. Riddell and son, I observed from $8\frac{1}{2}$ to $9\frac{1}{2}$ P. M., with a most perfect view of the whole heavens.

During this watch we saw eight conformable and sixteen non-conformable meteors. A majority of the former pursued paths near the milky way. I rose about 2 A. M. on the 4th and observed some minutes, without seeing any meteors.

August 4th.—From the same lookout and with the same aid, I saw only two conformable meteors, to thirteen *sporadic* meteors, in one hour's observation—$8\frac{1}{2}$ to $9\frac{1}{2}$ P. M. One of the meteors not conformable, was very magnificent, starting near Alioth in Ursa Major, and passing N. E., inclined some 60° to the horizon. It was much like a rocket in brilliancy, and pursued a halting course, as if obstructed and diverted by the atmosphere. No sound was heard after its explosion though it was expected.

August 5th.—Watched occasionally for meteors but saw only one conformable.

August 6th.—Made several observations during the evening and night, but without seeing a single meteor. It would seem that there is a cessation of the display.

August 7th.—On board a tow-boat, bound for the S. W. Pass, observed all the evening to $10\frac{1}{2}$ P. M. and saw only one conformable, and three sporadic meteors.

August 8th.—At Pilotsville, S. W. Pass, with a perfectly clear sky and perfect horizon, I observed two hours, without any satisfactory evidence that the phenomenon is continuing.

August 9th.—This night is the true anniversary of the August meteors;—being bissextile, the date is one day earlier.

On board the steamship Crescent City, from the mouth of the Mississippi, I commenced observation as the twilight faded, and soon was rewarded by the appearance of several brilliant meteors. The moon was very bright, obscuring stars of the third magnitude. In $2\frac{1}{2}$ hours observation on one-sixth of the heavens, I saw 16 meteors, conforming to the radiant in Perseus, and four irregulars.

Mr. Franklin Soule, editor of the New Orleans Mercury, aided me one hour, from 9 till 10 o'clock,—my own watch continuing till after 11 P. M.,—with intervals of clouds. Probably one-third of the visible meteors were obscured by clouds. This estimate would indicate about 144 meteors visible in the whole hemisphere in the $2\frac{1}{2}$ hours' observation,—and in the absence of a moon, not less than 100 per hour.

August 10th.—At three o'clock A. M., I rose for observation as the moon went down. The pilot of the boat informed me that the rockets were shooting all the time I slept. It was obvious at once that the number was greater than when I retired. From this time till daylight, $1\frac{3}{4}$ hours, I saw fifty-two conformable, and three sporadic meteors. A great number were very small, so that four of every five would have been invisible while the moon shone.

My view was very limited,—not more than one-eighth of the heavens being visible. But this was in the direction of the radiant point. This number would indicate near 300 visible meteors per hour, in the whole hemisphere. About one in three had no train; and about one-third seemed but a train or streak, without a nucleus. And of the sixteen with nucleus and train, eight were 10° long and four were 20° or more.

No sounds were heard. Some blazed before expiring. One left a white train, which was fifteen seconds in fading away. The color was uniformly pale white, except a few blazing ones.

The *center of radiation* for the August meteors has remained unchanged, in eleven returns I have witnessed of this phenomenon. A circle of about 3° radius, described from a center midway between the sword cluster, and γ Persei, and a little N. W. of the line joining them, would include all or nearly all the intersections of paths traced backward. I find it necessary to extend the area beyond my former limits of 4°, as several of the best marked meteors would otherwise be excluded. Several were seen to originate near the center of this area and move one, two or three degrees, and expire without leaving the circumference indicated. Two are recollected which moved in the

line of vision, so directly as to present a star growing in the first magnitude and dying in the same spot.

1849.—"On the night of August 3rd, 1849, I observed a meteor, which from its character and course of transit, I recognized as belonging to the annual display, having its maximum about the 10th of the month.

From the 3rd to the 10th nearly every evening was cloudy till a late hour; and incessant occupation prevented such observation as I could have desired. Mayor Blanchard and Dr. E. H. Barton reported to me, meteors which they saw on the 7th and 8th which evidently from description belonged to the display. They represented them as numerous and very brilliant, and coming from the northeast.

August 10th.—The clouds cleared away at $10\frac{1}{2}$ P. M., and I commenced observation from a position which commanded a view of about one-tenth of the heavens.

This field of view was from the head of Perseus, to a point 15° below the zenith and laterally as far as one could see, one tree covering the S. E. portion of the field. From Perseus to the horizon, a heavy cloud obscured the stars.

In one hour and fifteen minutes I counted twenty-six conformable meteors, and five sporadic. The moon rose meantime, and rendered the stars of the fourth magnitude invisible for the last half hour.

This portion of the heavens which I watched exhibited twice as many meteors as a field 90° distant, and about an equal number with a field directly opposite or 180° distant.

There was no perceptible change in the point of divergence. Several of the meteors originated within the circle. Assuming that the center is midway between η Persei, and the sword cluster, a radius of $2\frac{1}{2}$° would include all the intersections observed this year. This has not moved in eleven years.* The pale, white color of the trains, or phosphoric streaks across the sky, distinguish these from all other meteors.

August 11th.—This evening I observed from $9\frac{1}{4}$ to 10 P. M. with the largest possible field of observation, and no moon. I saw three regular and five irregular meteors, and Mrs. F. in half an hour saw two regular and three non-conformable meteors.

August 12th.—Observed from 9 to 10 P. M. with a good field and clear night, and saw no meteors of any kind."

For several subsequent nights I continued casual observation but without results, different from the last.

My observations for some years past have appeared in different papers and periodicals, those of 1847, in the Sidereal Messenger. Some of these publications suggest the earlier appearance of the display and these now offered seem to demonstrate a partial cessation about the 7th, thus dividing the phenomenon into two displays,—with however the same radiant point, and the same characteristic phenomena. If not before noticed, I invite the attention of observers from the 25th of July of each year.

Oleanda, Carrollton, La., Oct. 15, 1849.

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* See my observations from 1837 to 1840 inclusive, published in the Transactions of the American Philosophical Society.

V. Miscellaneous Intelligence.

1. *Translation of part of a letter from Mr. E. F. de Furuhjelm, one of the officers of a Scientific Expedition sent out by the Emperor of Russia to the Northern part of Finnland and Lapland, to Oscar M. Lieber;* dated Kurfamo Kappmark, 67° N. L., July 28, 1850. (Communicated for this Journal.)—"At the beginning of June, I left Helsingfors for Uleaborg, about eighty Swedish miles or six hundred and forty English. In the latter town I had to provide myself with a suitable outfit for Lapland—tents, provisions, a cook, &c. There remained yet two hundred English miles to Kuusamo Kirube. The distance took us six or seven days, though hitherto we had traveled at the rate of eight miles an hour. The stations where we could procure horses became fewer and fewer, and frequently I was obliged to wait one or two days for horses. At Kuusama church all roads were at an end, and thence I was obliged to travel either on the lakes and rivers or on foot. When I say I am now in Lapland, I am wrong, for in this parish no Laplanders have lived within the last hundred years. Finnish colonists have pressed them on farther North, somewhat as has been done with your Indians. They have here some little agriculture (rye), and a few settlements. From ten to twenty miles farther north, we have the true Laplanders, who roam about with their reindeer. The scenery here partakes, however, entirely of the Lapland features. Summer lasts only from ten to twelve weeks; and in December the day lasts from eleven till two o'clock, and even these three hours are not what we would call daylight, but rather a kind of twilight. A few miles farther on they do not see the sun at all for a whole month. The population here is very sparse; fishery and breeding of cattle furnish the only means of subsistence. Reindeers are much used: a rich peasant has from three to four hundred; the Laplanders several thousand. Very few are seen here in summer, for, as soon as the snow thaws in spring, they are driven into the forests. In autumn almost the whole population go out; a large space is fenced in, and after tedious driving, they collect the half wild reindeer, and each individual selects his own—they are all marked—and takes them home. The whole winter the reindeer keep round the bays and inlets, and feed themselves by scraping out the moss from under the snow, and the peasants consequently do not have to look out for their feeding. For the winter, some dozen or two are broken in for the harness, for there are few horses here, and higher up none. A reindeer sledge (in Lapplandish *pulka)* is shaped like a boat *(conat)*. Reins are not used as with horses, only a strap round the neck. The animal may be in quickest motion, but so soon as I pull the strap to the side, it stands still. In driving in the *pulka*, we make use of cloaks of reindeer hide, through a hole in which the head is thrust. * * * Almost the whole of June, I could see the sun all night from the hill tops, considerably above the horizon. Night was as light as day, and I could make the most careful drawings and minute examinations of minerals. In June and July, we had intense heat, accompanied by innumerable gnats and flies. The peasants guard themselves against these tormentors by covering their face and hands with tar; I had a mask of gauze.

"Our expedition is headed by an old officer who is appointed to conduct the whole. * * * I am the second in command, as officer of the scientific department, and have a good deal to do. I direct where the men are to wash for gold, make geological maps and sections of the country, conduct the test-diggings for veins of various metals, &c. Then comes a man who has to see to order and discipline among the hands, to furnish provisions and keep up the communication, besides acting as paymaster. Then two gold-washers (Quartermen) who have learnt their trade in the Ural. A carpenter and blacksmith, and then fifteen or sixteen hands to dig, in all about twenty to twenty-five individuals. * * * The expedition costs the government about thirty or forty dollars a day, and as yet has not paid a cent! Living is rather cheap in these regions; I might live conveniently for about five cents a day, but as it is, what with a cook, tea, wine, and other things more or less luxuries, it amounts to about fifteen.

"Search for gold is always made in small valleys watered by creeks. The auriferous soil rests on plutonic and metamorphic rocks, e. g. mica-slate, clay-slate, diorite, (very common,) and always with sulphuret of iron, frequently sulphuret of copper. The gold generally occurs two feet from the surface, and is usually found in sand and clay, fine and coarse, together with rolled masses of rock, and always containing magnetic iron-sand, locally termed *Schliech*. The gold occurs only in minute particles. Since the 14th of June, I have examined about sixty valleys, and in all found gold, but as I have said, scattered very sparingly and in small grains."

2. *Notice of a remarkable Spring or fountain in Hollis, now Phipsburg, Maine, about seven miles from Saco and Kennebunk;* (communicated by the Rev. J. COGSWELL, from New Brunswick, N. J., November, 27, 1849.)—To Prof. SILLIMAN:—The fountain of which several years ago you requested me to communicate to you an account is situated in a hollow near a pine plain, about sixty rods S. W. from the lower meeting house in the town above named.

By accurate measurement the basin is sixty feet long, twenty-five broad, and four and a half deep—and this depth of water is at all seasons nearly invariable. The bottom is a hard, smooth surface of white sand, through which the water, at five or six places, occasionally breaks forth with so much force that an observer looking through the clear water upon a smooth bottom, is disposed to start back. When boiling the water is white and turbid and resembles in its ebullition that of the slaking of lime. After continuing two or three minutes, it ceases and the place through which the boiling took place, becomes smooth and so hard that it is difficult to press into it with a sharp pointed pole. When the boiling ceases in one place it breaks through in another; and it hardly ever ceases to boil in all parts at once. In a very few minutes after the boiling ceases in any particular place, the water becomes clear. The spectator, while he is looking on, may see the water break through in five or six places in succession, often irregular. When the sand is taken from the spring it coheres very closely, and when trodden under foot it gives a sound like that of a sled passing in cold weather over the snow. The sand is used for plastering and for sharpening instruments. The water is at the common temperature, and has

no peculiar taste. It issues from the fountain in a considerable stream, and about six miles below it falls into Saco river.

Remark.—As Dr. Cogswell, who has often visited this fountain, makes no mention of gas, we must presume that the force is hydraulic, and that this is probably an intermitting or perhaps more properly a remitting fountain, similar although inferior in power to the thundering spring near Mobile in Alabama.

3. *Barometric Observations made during a journey from Albany, N. Y., to the summit of Mount Washington in New Hampshire;* by Joel W. Andrews, Albany, N. Y., 1850, (communicated for this Journal.)—The barometer used in the following observations has a calibre of 0·29 inch, and a glass cistern and a zero point to adjust the level of the mercury for each observation.

The attached thermometer is let into the instrument and covered with glass.

Place of Observation.	Distance in miles.	Time.	Hour.	Barometer.	Thermometer.
Albany, No. 42 High st., 100 feet above tide-water in the Hudson River, weather fair and calm,		July 25	6 A. M.	29·944	74°
East Bennington, Vt., near state house,	28	" "	2 P. M.	29·386	80
South Shaftsbury, Vt., near post office,	5	" "	P. M.	29·294	75
Shaftsbury Centre, Vt, " " "	2	" "	6 P. M.	28·926	70
Arlington, Vt, " " "	7	" "	7 P. M.	29·406	64
Manchester, Vt, near stage house,	8	" "	9 P. M.	29·220	67
" " " " " weather fair,	"	July 26	6 A. M.	29·26	61
East Dorset, Vt, near post office, about three-quarters of a mile from the summit level of the Otter Cr., and the Battenkill,	6	" "	A. M.	29·40	62
North Dorset, Vt.,	4	" "	A. M.	29·442	62
Danby, Vt.,	4	" "	A. M.	29·48	64
Wallingford, Vt., near post office, fair,	9	" "	A. M.	29·576	65
East Rutland, Vt., Village,	9	" "	12 noon	29·51	70
" " " "	"	" "	5 P. M.	29·45	68
" " " Mussey's tavern, near the foot of the Green Mts., west side,	3	" "	7 P. M.	29·408	61
Sherburn, Vt., Rufus Richardson's tavern, east side of the Green Mts., near the Queechy R.,	9	" "	10 P. M.	28·90	58
Sherburn, Vt, Rufus Richardson's tavern, east side of the Green Mts, near the Queechy R.,	"	July 27	6 A. M.	28·916	60
Bridgwater Valley, Vt., near the Queechy R., weather fair,	11	" "	9 A. M.	29·284	68
Woodstock, Vt, near stage house,	6	" "	$10\frac{1}{2}$ A. M.	29·446	76
White River Junction, Vt., level of the Connecticut and White R., under the railroad bridge,	10	" "	P. M.	29·802	76
Bath, N. H., near stage house,	45	" "	6 P. M.	29 54	76
Littleton, N. H., near Cobleigh's hotel,	15	" "	9 P. M.	29·212	66
" " " " " weather fair,	"	July 28	7 A. M.	29·212	62
Carroll, N. H., Mr. White's, White Mtn. house, near Ammonoosuc R.,	20	" "	12 noon	28·156	74
Carroll, N. H, Mr. White's, White Mtn. house. Start for Mt. Washington,	"	July 30	7 A. M.	28 40	71
Flat Rock, crossing the Ammonoosuc R., weather cloudy, sky overcast all day,	3	" "	$9\frac{1}{2}$ A. M.	28·12	76
Foot of the Mountain, crossing the Ammonoosuc R., weather cloudy, sky overcast all day,	2	" "	$10\frac{3}{4}$ A M	27·354	72
Fabyn's Camp, about half way up the mountain,	2	" "	$11\frac{3}{4}$ A M	26·10	68
Summit of Mt. Washington, (6 feet below,) (Returning from Mt. Washington.)	2	" "	$1\frac{3}{4}$ P. M.	23·944	64
Fabyn's Camp,	2	" "	$3\frac{3}{4}$ P. M	26·10	65
Foot of the mountain, crossing the Ammonoosuc River,	2	" "		27·354	72
Flat Rock, crossing the Ammonoosuc R.,	2	" "	$5\frac{3}{4}$ P. M.	28·114	72
White Mountain house,	3	" "	7 P. M.	28·40	70

Second day to Mt. Washington by way of Mt. Pleasant, weather fair and calm all day.

Place of Observation.	Distance in miles.	Time.	Hour.	Barom-eter.	Thermom-eter.
White Mountain house, ...		July 31	8 A. M	28·486	80
Flat Rock, crossing the Ammonoosuc River,	3	" "	9¾ A. M.	28·21	78
Summit of Mt. Pleasant, ...	4	" "	12 noon	25·41	72
Summit of Mt. Washington, (6 feet below,)	2	" "	2 P. M.	24·032	68
(Returning by way of Fabyn's Camp.)					
Fabyn's Camp, ...	2	" "		26·18	72
Flat Rock, crossing the Ammonoosuc River,	4	" "	6½ P. M.	28·184	72
White Mountain house, ...	3	" "	8 P. M.	28·49	72

By the foregoing observations I have ascertained the height of Mt. Washington as follows:

From tide water at Albany to the White Mtn. house,	1622·3
From White Mtn. house to summit of Mt. Washington,	4868.3
Distance of the instrument below summit, . .	6·0
Height above tide water, ...	6496·6

By my observation on the first day, July 30th, I make the height 39 feet less.

4. *Makerstoun observations on the Aurora Borealis;* by J. Browne, Esq., (Proceedings of the Royal Society of Edinburgh, vol. ii, 1850, No. 39, p. 344.)—A table of 184 auroræ seen at Makerstoun in years 1843 to 1849 is given in pages lxxv—lxxviii of vol. xix, part 2 of the Edinburgh Transactions; from this table the following results have been obtained:

A very careful outlook for auroræ was kept up throughout the whole period but especially during the first five years; an outlook warned by magnetic disturbance in circumstances unfavorable to the visibility of the meteor, and assisted by a practical acquaintance with the faintest auroral indications. In several cases, the auroral appearances were very faint; these are entered in the table as "Traces," and, in others, there was doubt whether the appearance was truly auroral; these are indicated by "Trace?" It should be noted that, with the exception of the years 1844 and 1845, auroræ were seldom looked for after midnight.

Diurnal variation of frequency of the Aurora Borealis.—The following are the numbers of times when auroræ were seen, at each hour, from 5^h P.M. till 5^h A.M., for the whole period—referring to the printed tables for the numbers for each season.

Hour,	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.
No.,	5	19	45	57	91	75	50	37	27	15	11	3	2

The greatest number of auroræ were seen at 9h P.M.; this result is independent of the effects of twilight, since 9h P.M. is also the hour of maximum frequency for the winter months. This hour is nearly the hour of maximum disturbance for the magnetic declination and dip; as, however, the maximum disturbance of the total magnetic force and a maximum of the magnetic dip appear to occur about 5h P.M., this also may be an epoch of maximum frequency or intensity, though this can only be determined in higher latitudes. It should also be remarked, that, since the epoch of maximum disturbance varies with the season,

so, therefore, it is probable will that of the frequency of the aurora ; some traces of this may be deduced from the previous table. In the winter quarter, November—January, four-fifths of the times at which auroræ were seen were for the hours *before* 10h P. M., whereas in the spring quarter there were only three-fifths seen before 10h P. M.

Annual Variation of frequency of the Aurora Borealis.—The first line following contains the numbers of auroræ observed in each month during the six complete years 1843–8, and the second line gives the numbers of hours at which the auroræ were seen.

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	16	26	14	6	0	0	7	13	27	23	11
50	62	65	43	8	0	0	10	32	44	58	38

The greatest number of auroræ were observed in March for the first six months, and in October for the last six months of the year ; none were observed in June and July. When the six months of 1849 are included, the number for February is twenty-six, and for March twenty-eight. The law of visible frequency of the auroræ is the same as that deduced already for magnetic disturbance ; namely, maxima near the equinoxes, and minima near the solstices, the minimum at the summer solstice being the principal. As, however, the shortness of night during the summer months must diminish the number of visible auroræ, it is by no means certain from these numbers that a minimum occurs at the summer solstice ; the fact of the minimum at the winter solstice is involved in no such difficulty. If we could assume that the auroræ had the same diurnal law of frequency at all seasons of the year, the existence of the summer minimum could be satisfactorily determined, by comparing the numbers of times which auroræ were seen at the five hours, 10h P. M.–2h A. M., during which (even in the months of August and May) there is little twilight to extinguish auroræ. The numbers are as follow, for these five hours in each month of the years 1843–8 :

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	24	38	31	8	0	0	9	14	16	18	12

From these it is evident that the numbers in May and August are certainly less than for April and September ; but it has been already mentioned as probable that the diurnal law of frequency varies with the season, of which, indeed, a proof is to be found in the great excess of the numbers above for the spring months, compared with those for the autumn months, showing the later epoch of the maximum frequency in the former. An examination, however, of the table for the disturbance of the magnetic declination (Table 18, vol. xix., part 2,) will show that, though the maximum disturbance occurs after midnight in the months of May, June, and July ; yet in August and the two following months it occurs about 10h P. M., so that there can be no doubt of the less number for August than for September and October, if there should be a doubt in the case of May compared with April. The difference, however, even in the latter case is too great to be explained by any slight shift of the epoch of maximum frequency in the two months. Upon the whole, it appears certain that a minimum of actual as well as of visible frequency occurs in summer ; a result quite in accordance with

that for the amount of magnetic disturbance, which accordance is sufficiently close to permit us to complete it, by assuming that the number of auroræ is a *principal* minimum in summer.

It has been stated in the volume for 1844, p. 401, that this result was long ago obtained by Mairan; this statement, made chiefly on the authority of Kæmtz and Hansteen, is not quite accurate. It is true that Mairan's numbers give a rough indication of the law, as will be seen below; but when it is remembered that his table includes all the observations (229) of which he could find a record for upwards of 1,000 years, it will be evident, that the conclusion that a greater number of auroræ occurred at both equinoxes than at the winter solstice would have been hasty; this conclusion, however, is *not* made by Mairan, and, though he has combined the numbers of auroræ in a great variety of ways, he has made no combination exhibiting this fact. It did not enter into the necessities of his theory (that auroræ are the product of the solar atmosphere) to show that a greater number of auroræ happened in the northern hemisphere at the vernal equinox than at the winter solstice; he shews, indeed, that the number for one equinox is, and, in accordance with his theory, ought to be greater than for the other. Some other philosopher has the merit of first pointing out this fact.

The following are the numbers of auroræ by Mairan (Traité Physique et Historique de l'Aurore Boreale par M. de Mairan, 1733, p. 199); by Kæmtz (Complete Course of Meteorology, translated by Walker, p. 458); and by Hansteen (Mem. de l'Acad. Roy. de Belgique, t. xx, p. 117.)

	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sum.
Mairan, .	21	27	22	12	1	5	7	9	34	50	26	15	229
Kæmtz, .	229	307	440	312	184	65	87	217	405	497	285	225	3253
Hansteen, .	29	31	47	34	2	0	0	17	35	33	34	23	285
J. A. Broun,	22	26	28	16	6	0	0	7	16	29	23	11	184
Sum of last three,	280	364	515	362	192	65	87	241	456	559	342	259	3722

Mairan's numbers are probably included by Kæmtz; a few of the auroræ, included in M. Hansteen's list, are identical with those in my own.

Variation of the frequency of the Aurora Borealis with the Moon's Age.—This investigation is evidently beset with considerable difficulty, since the moonlight existing nearly extinguishes the appearances of all the fainter class of auroræ, and it renders the faintest wholly invisible; the careful watch, however, which was kept for auroral appearances at Makerstoun, probably renders the table given in the Transactions better fitted for such a question than any previous series of observations.

It should be remarked, that the latitude of Makerstoun, or perhaps even a lower latitude, is better fitted for this investigation than much higher latitudes; at least this is the case as long as only frequency of visibility can be considered. The French *Commission du Nord*, during their stay in Lapland, found auroræ existing, or probably existing, almost every night. In such places variation of frequency there is none, and variation of intensity alone remains for investigation. It is obvious,

that till some better mode of measuring this intensity can be devised for these high latitudes, we are forced to perform this operation in a rude manner, by moving to lower latitudes, where the fainter auroræ become invisible, and where, therefore, frequency is a test of intensity beyond a certain limit.

Combining the numbers of auroræ observed at each day of the moon's age into six groups of five days, (the first group, four and a-half days,) we find the average number of auroræ for one day of the moon's age in each group as follows, from the six and a-half years' observations:

Moon's age,	28d—2d	3d—7d	8d—12d	13d—17d	18d—22d	23d—27d
Number,	5·8	5·2	3·6	5·0	10·2	6·6

Did auroræ *occur* indifferently at all ages of the moon, we should expect to *see* the greatest number at conjunction, and the least number at opposition; this, however, is not the case, the greatest number was seen about two days before the end of the third quarter, and the least number about two days after the first quarter, or the visible maximum and minimum occurred at times *equidistant* from the epoch of opposition.

The frequency of auroræ, therefore, is a function of the moon's age. In order to determine the actual law, we may consider the probable effect of moonlight in obliterating the auroral appearances; remarking, first, that 9h P.M. is the epoch of maximum frequency for the aurora, and that upwards of five-sixths are seen before midnight. When the moon is about three days old, in the months from September to March, it begins to set sufficiently late, and to have sufficient light to render the earlier of the faint auroræ invisible; about the end of the first quarter, it does not set till midnight, and thus shines throughout the period of the occurrence of five-sixths of the auroræ: afterwards it increases in brightness and the maximum effect in extinguishing faint auroræ is evidently attained at opposition, when the moon begins to rise late enough to allow the earlier auroræ to be visible; towards the end of the third quarter when the moon does not rise till midnight, it is also evident that the number of faint auroræ rendered invisible must be very small. From the beginning of the fourth quarter, therefore, till conjunction, the numbers *seen* will obey nearly the true law of frequency; and as the visible maximum occurred before the end of the third quarter, the true maximum must have occurred even nearer to opposition. On the whole, it appears very certain, that the hypothesis of an actual maximum of frequency at opposition, and minimum at conjunction, is satisfied by the previous numbers of auroræ seen under the conditions of the varying duration of moonlight for the hours of maximum frequency. This hypothesis is in unison with the law of magnetic disturbance, which is a maximum at opposition, and a minimum at conjunction.

4. *Relative level of the Red Sea and Mediterranean*; (L'Institut, No. 874.)—The following measurements are by the engineers attached to the Expedition to Egypt in 1799, and by Bourdaloue charged in 1847 with examining and levelling across the isthmus.

	Expedition.	Bourdaloue.
Low water at Tineh,	0m·00	0m·00
High water at Suez,	9 ·90	2 ·27
Low water on the Nile at Mekias,	5 ·29	13 ·27

Bourdaloue's results, so different from the others, were obtained with excellent instruments and seem to be every way worthy of confidence. His investigations extended from Cairo to the mouth of the Nile; from Cairo to lake Temsah, near the centre of the isthmus, by the valley of Ouadeé Toumilat, and thence in two lines, one to Tineh and the other to Suez, the former sixty and the other seventy-five kilometers in length. Bourdaloue made two verifications of his measurements, which agreed very nearly with his principal measurements.

5. *Fall of Dust at Olsterholz, near Detmold;* (Monatsber. Berlin Acad., April, 1850.)—This fall of dust accompanied snow, with the wind from the southwest, in February, 1850, and it covered the earth to a thickness of two-thirds of a line. Ehrenberg has detected in it fifty organic forms of which forty had been observed by him in similar circumstances, while ten species were for the first time observed in dust transported by the winds. None of the species were new.

6. *Tenacity of Metals*, (Comptes Rendus, Juillet 29, 1850; Phil. Mag., Oct., 1850.)—As the results of numerous experiments, M. Baudrimont has arrived at the following conclusions:—

1. That the tenacity of metals varies with their temperature.
2. That it generally decreases, though not without exception, as the temperature rises.
3. That with silver the tenacity diminishes more rapidly than the temperature.
4. That with copper, gold, platina and palladium, it decreases less rapidly than the temperature.
5. That iron presents a very peculiar and remarkable case: at 212° F. its tenacity is less than at 32°; but at 392° its tenacity is greater than at 32°.

7. *Note.*—The views on the relations of vegetable development and the alternations of generation in Radiata, brought forward in the last volume of this Journal, p. 34, have been since found by the writer to have been recently presented, but at an earlier date, by Dr. W. B. Carpenter.—J. D. D.

8. Obituary.—The following letter, here cited from the Proceedings of the Academy of Natural Sciences at Philadelphia, announces the death of Dr. William Gambel, a naturalist of extensive attainments in science, especially in Botany and Ornithology, and highly esteemed by all who knew him for his nobleness of heart and personal worth. The letter is dated Mountain House, Alta California, March 25, 1850, and is addressed to the editors of the N. American and U. S. Gazette of Philadelphia.. Dr. Gambel died on the 13th of December of last year.

Messrs. Editors,—I trust you will pardon the liberty I take in offering to the citizens of Philadelphia, through your valuable paper, a tribute to the memory of an eminent and worthy Philadelphian, who has fallen in this wild and far-off country. I refer to the death of Dr. William Gambel, former Secretary of the Academy of Natural Sciences of your city, who left for California in the spring of 1849, taking the overland route, to collect specimens illustrating the natural history of the Far West, and to explore, to some extent, the prominent geological features of the country between the Rocky Mountains and the Great Sierra Nevada.

He went from Independence to the upper crossing of the Kansas with a small company of gentlemen from Georgia, Florida and Virginia. After which his company joined Indiana Company, No. 1, of which I had command, and with us he continued until we reached Fort Kearney, on the Great Platte. There he separated from us and joined a company commanded by Captain Boon, of Kentucky, which followed the trail opened by Captain Hudspeth's company, crossing the Sierra, near the head of Sacramento valley. The trials of this rugged route across fearful mountains and great deserts proved too much for the Doctor's constitution, and on reaching his destination in California, he was seized with typhoid fever, of which he died. He had collected during his journey a large number of rare and interesting specimens, by which he had added largely to the rich store of knowledge he had previously gained. His loss is as sad as it is premature, and he sleeps in peace beneath the towering pines which cluster on a sunny hill-side stretching up from the bright waters of the *Rio de las Plumas*. He has departed early, but not unhonored, and though the afflicting dispensation will fall heavily on those to whom he was endeared by ties of relationship or friendship, yet their consolation will be strong in the knowledge that he fell in the midst of his honorable pursuit of knowledge, and the earnest and zealous unfolding of his natural and acquired gifts. Philadelphia owes to his memory a lasting tribute of respect for his science, virtue, worth, talent, and energy. Yours, D. B. Woods.

VI. Bibliography.

1. *A Discourse on the Studies of the University of Cambridge*; by Adam Sedgwick, M.A., F.R.S., Woodwardian Professor and Fellow of Trinity College. 5th edition, with additions and a Preliminary Dissertation. ccccxlii, and 322 pages, 8vo. London: 1850. J. W. Parker.—This admirable discourse, by Prof. Sedgwick, occupies but 94 pages out of the 760 that constitute the volume. The additions in the way of Preface and Notes have rendered it a full Treatise on the important subject of which it treats. The learned author, appreciating the truths and spirit of religion as well as of science, ably sustains his views against the materialism and Pantheism of the day. The argument of the Vestiges of Creation is shown up in its true light, as weak in logic and false in facts notwithstanding the plausible air which pervades the work. After much spirited argument, alternately severe and playful, Prof. Sedgwick observes, page 285:

I can find, here and there, within *The Vestiges*, something almost to match Oken's Snail*—"the exalted symbol of mind slumbering deeply within itself—the prophesying goddess sitting on a tripod!" Both Au-

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* "Circumspection and foresight appear to be the thoughts of the Bivalve Mollusca and Snails.

"Gazing upon a Snail, one believes that he finds the prophesying goddess sitting upon the tripod. What majesty in the creeping Snail, what reflection, what earnestness, what timidity and yet at the same time what firm confidence! Surely a Snail is an exalted symbol of mind slumbering deeply within itself."—*Oken's Physiophilosophy*, Transl. published by the Ray Society. p. 267.

thors have long sat, slumbered, and dreamed under the *arbor Dianæ*. The Edinburgh Reviewer exhorted our Author to quit his seat; and told him that if he remained there, he might be stricken on the head, and have his cerebral organs shamefully put out of tune, and made to jar against all rules of harmony. The goddess, though chaste, is very mischievous. No divinity of the sky so fickle, and of so many faces:—and her motions are so wandering and inconstant, that they have puzzled and confounded the wisest heads since the days of Newton. But under the *arbor Dianæ* our Author still is sitting; and there it was that he evolved, in solitude, some of the queerest visions of his fantastical philosophy. We may take a passing view of one or two of them.

"After Man, the Order of *Primates* takes in Monkeys, Lemurs, Bats, and Sloths; and this Order rests on the Dolphin family. In this family each cerebral hemisphere is made of three lobes, as in Men and Monkeys. "It might be rash," says the cautious Author (*Vestiges*, p. 341), "to found any thing upon ancient accounts of the Dolphin—its familiarity with man, and its helping him in shipwreck—although it is difficult to believe these stories to be altogether without some basis of fact." He must have been napping under Diana's tree, thus to cut short his tale. Why did he not tell us of a man who, while Periander was king of Corinth, came over from Sicily riding cheerily upon a Dolphin's back? There is better historical evidence for this fable than for some others, quite as strange, that are vouched for in the *Vestiges*. But he adds, even while broad awake, "there is no doubt that the Dolphin evinces a predilection for human society, and charms the mariner by the gambols which it performs beside his vessel"—especially (he should have added) while it is catching the flying fishes. But does not the Shark also show the strongest internal love of the human family, though our Author thinks it hardly deserving of a place among the Vertebrates?

"'He may not be held a very fanciful naturalist who would regard the Megatherium as eager to climb the tree which he could only shake, and thus producing a progeny fitted to do that which was the object of his wishes;—or the Rock-nose Whale, which loves to rest its head on rocks beside the beach, as wishful of that mode of life which was at length vouchsafed to a more highly developed descendant. Such too may be found to be the true principle of perfectibility in nature—a continual, though it may be an irregularly shewn tendency, to press on to better and better powers—and indefinite improvableness, which may work as seconds in the individual, or strike hours in the species,' (vide p. 346.) But why does our author thus venture to steal the mantle of Lamarck and the elder transformationists? He had no right to stick their feathers in his plume. They told us that the Elephant rose upon the earth with a short neck—that he gazed unhappily on foliage he could not reach, and so his face was lengthened—that it was afterwards more lengthened till his snout could reach the branches—that his nose became prehensile—that he tugged at the branches with it till it was pulled into a trunk—and that then this feature became as stable as that of any other

happy Mammal. But our Megatherium worked another way. She was too heavy in her hinder parts to climb; but nature had given her gigantic strength; so she shook the trees of the old forests and tore them down, and then fed on their branches. But she was weary of this work, and sometimes (as we know) broke her head in doing it. So she wished for some mechanism to spare her all this trouble. Nature heard her prayer, and she brought forth a litter of climbing Sloths; which now disport themselves joyfully in the tree-tops, and spend their lives among the dishes of their ready banquet! We have all heard of the 'vanity of human wishes,' and we have all read, in our younger days, the merry tale of the three wishes and the ladle. Wishing, after all, seems to be but a sorry business. But, says our Author, Creation is now 'a fact accomplished;' and we have no right 'to expect the origination of species to be conspicuously exemplified (after this fashion) in the present day,' (vide p. 80). We do indeed still hear of the marvelous effects of pregnant longings even in the human species: but they sink into the shade in comparison of the natural progeny of wishes in the days of the Megatherium or the Rock-nose Whale, and the perfectibility of nature which strikes hours in the species, are, after all, I fear, but the jarring sounds of a smitten organ—the cerebral blights of Diana's tree." And also, page 288:—

"But I beg the reader's pardon; I am only speaking of the Author's dreams; and in truth he is an honest dreamer. Many a time during past years (while the Chimpanzee was living) have I wished for some clew to guide me to his hiding-place, that I might have the comic happiness of drawing him from the shade of Diana's tree, and going with him to the Zoological Garden of London, there to witness the emotions of his filial love while he was gazing on the solemn visage of one in the very type of his immediate ancestors. 'Not for nothing would he have started' at that perfect image of 'anticipated humanity!'"

2. *Elements of Natural Philosophy;* by W. H. C. Bartlett, LL.D., Professor of Natural and Experimental Philosophy in the U. S. Military Academy at West Point. Section I, Mechanics. 632 pp. 8vo. New York: 1850. A. S. Barnes & Co.; Cincinnati, H. W. Derby & Co.—The author of this excellent and well illustrated work, states in his preface that this volume is the first of three in which he proposes "to offer to academies and colleges, a course of Natural Philosophy, including Astronomy." This volume treats of Mechanics, and is independent of those which may follow. It is printed in type of good size, and marginal notes direct to the subjects of the paragraphs.

3. *The Recent Progress of Astronomy, especially in the United States;* by Prof. Elias Loomis, N. Y. University. New York: Harper and Brothers, 1850. 12mo, pp. 257.—The nature and plan of this valuable work will be best understood by an enumeration of the titles of the different sections, which are these. *The discovery of the Planet Neptune; do. of several Asteroids; do. of an Eighth Satellite of Saturn; New Observations of the Satellites of Uranus; Great Comet of* 1843; *Faye's Comet of* 1843; *De Vico's Comet of* 1844; *Return of Biela's Comet in* 1846; *Miss Mitchell's Comet; Expected Return of the Comet of* 1264; *Determination of the Parallax of Fixed Stars;*

Observations of New and Variable Stars; Distribution of the Stars in space; Motion of the Sun and Fixed Stars; Resolution of remarkable Nebulæ; History of American Observatories; Astronomical Expedition to Chili; Astronomical Results of Public Surveys; Determination of Longitude by the Electric Telegraph; Astronomical Publications; Manufacture of Telescopes in the United States.

The design of the work is to exhibit in a popular form the most important astronomical discoveries of the last ten years. The author has executed the task with his usual thoroughness and accuracy, and the student is here furnished in a condensed and reliable form with a large amount of important information, to collect which from the original sources would cost him much time and labor.

One omission should be noticed. We do not find in this volume any allusion to Kirkwood's celebrated law connecting the rotations of the planets with their masses and distances from the sun. In a history of American Astronomy especially, this discovery is entitled to an honorable mention.

4. *New Elements of Geometry;* by SEBA SMITH. 200 pp. 8vo, New York, 1850: G. P. Putnam.—The author calls Euclid to account for asserting that "a line is length without breadth" and "a surface is length and breadth without thickness." These definitions he declares to be false—a verdict that will be pronounced upon Mr. Smith's work by those who are not convinced by his arguments, among which number we happen to fall.

5. *Practical Hand-book of Medical Chemistry;* by JOHN E. BOWMAN, Fellow of the Chemical Society, London, &c. 288 pp. 12mo. American edition. Philadelphia, 1850, Lea & Blanchard.—This volume treats in Part I, of the Urine in all its conditions healthy and morbid; in Part II, of Calculi and Concretions; in Part III, of the Blood; Part IV, of Milk, Mucus, Pus, Bone, etc.; Part V, of the detection of various Poisons in organic mixtures, &c. It brings together information of great importance to the medical student, with a fullness of detail and illustration that will render it practicaliy useful. The forms and appearances of crystallizations of salts are well represented by figures, and also the microscopic character of such organic matters, healthy and unhealthy, as are treated of. Modes of analysis are described and the composition of the more important of the substances mentioned is given.

6. *Geological Report on the Lake Superior Copper Region, Michigan;* by CHARLES T. JACKSON, M.D. Executive Document, No. 1, 31st Congress, 1st session. 566 pp. 8vo. Washington, 1849.—This Report by Dr. Jackson has been slow in appearing, owing to delays in its publication. It is greatly to be regretted that the valuable documents of Congress are printed on paper so poor and in a style so far below all ordinary publications of the day. There is certainly no reason in the nature of things why our government should not be as well served by its printers as the publishing houses of New York or Boston. We observe also with regret many typographical errors in this Report, which could not have been overlooked if the proofs had been sent to the author, or were read by one acquainted with the subject.

Dr. Jackson was one of the earliest explorers in the Lake Superior Copper Region, and some of the mines were first laid open by him. In the course of his investigations he has brought to light much valuable information, among which are many curious and interesting facts relating to the association of native copper and silver with the minerals of the amygdaloid of the region. A large part of his results have appeared in this Journal in former volumes,* and the last volume contains a resumè of his observations made as a Report to the American Association at Cambridge in 1849. It is not necessary therefore to enter into a detailed review in this place. The Report commences with a historical account of the working of the copper mines in former periods, and then proceeds to descriptions of the region, its explorations and mineral productions. Several analyses are given of rocks and minerals.

The volume contains a large number of maps, geological and topographical, besides some views. There are also catalogues of geological, mineralogical and botanical specimens.

7. *The Daguerrian Journal, devoted to the Daguerrian and Photographic Art, also embracing the Sciences, Arts and Literature;* semimonthly in numbers of 32 pages, 8vo. New York City, S. D. Humphrey, Editor and Publisher.—The rapid progress of science in this age is well seen in the fact that an art unknown a dozen years since now demands a separate Journal for the publication of the new facts and improvements daily coming to light. In this short time, as the Daguerrian Journal states, the number of artists in this profession has increased in America to ten thousand; and we believe that the skill here exhibited is acknowledged to be even superior to that of the land of Daguerre. This Journal is practical as well as scientific in character, and includes also information and criticisms on subjects connected with other popular arts as well as Painting and Sculpture.

8. *A Practical Treatise on the Construction, Heating and Ventilation of Hot-houses, including Conservatories, Green-houses, Graperies, and other kinds of Horticultural structures, with practical directions for their management in regard to light, heat and air:* by Robert B. Leuchars, Garden architect. 366 pp. 18mo, illustrated with numerous engravings. Boston, 1851. J. P. Jewett & Co.—This work is full of sound sense and science, and comes from a man well versed in his favorite art from much experience among the most extensive gardens of England. It is well fitted to be a guide in the construction and arrangement of horticultural structures, being complete in its details and judicious in advice. The various kinds of arrangements hitherto proposed are discussed, and whatever errors they contain pointed out, with a full explanation of their principles on scientific and practical grounds. The work closes with a number of tables relating to the atmosphere, vapor, dew-point, and other matters having a bearing on practical horticulture.

9. *Art's Echo of Science, Inventions and Patents;* a monthly of 16 pp. 8vo, commenced Aug., 1850. Edited by J. L. Kingsley and

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* Vol. xlix, p. 81, and 2nd ser., ii, 118; vii, 286; x, 65.

Abram Longbottom, Civil and Mechanical Engineers and Solicitors of American and European Patents. New York.—This new Periodical is devoted more especially to the various practical arts, which are treated in a popular manner.

10. *Journal of the Academy of Natural Sciences of Philadelphia*, 2nd ser., Vol. II. Part I. Contents :—

J. L. LeConte: An attempt to classify the Longicorn Coleoptera of the part of America north of Mexico. (Concluded from p. 340, vol. I.)

T. A. Conrad: Descriptions of one new Cretaceous and seven new Eocene Fossils, (with a plate.)

J. Leidy: Descriptions of some American Annelida Abranchia, (with a plate.)

J. Cassin: Descriptions of Owls, supposed to be new, (Syrnium virgatum, S. albogularis, and Nyctale Harrisii,) in the collection of the Academy, (with three colored plates.)

W. Gambel: Description of a new species of Mergulus (M. Cassinii) from the coast of California, (with a colored plate.)

D. D. Owen and B. F. Shumard: Descriptions of new Crinoidea, from the sub-carboniferous limestone of Iowa, (with a plate.)

J. Deane: Fossil Footprints of the Connecticut valley, (with two plates.)

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ERRATA.

P. 18, l. 16 from bottom, for "space," read "sphere." P. 22, l. 5 from top, substitute f for f. P. 23, l. 13 from bottom, for "any portion of *cgrs*," read "any portion *cgrs*." P. 24, l. 15 from top, for $\frac{d^2P}{ds}\,d\,\xi$ read $\frac{d^2P}{ds\,d\,\xi}\,d\,\xi$. Page 33, line 8 from bottom, for πKR^2 read $2\pi KR^2$. P. 34, l. 4 from top, for $\frac{d^2\,Q'}{d\,t}$ read $\frac{d^2\,Q'}{d\,t^2}$.

P. 108, l. 12 from bottom, for "anilene," read "amilene." P. 110, line 22 from bottom, for "$C_{14}H_5O_4+4HO$," read "$C_{20}H_6O_6+4HO$." P. 112, l. 19 from bottom, for "urthethan," read "urethan."

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The recommendation of the *Cherry Pectoral* (so-called) signed by my name is a *forgery*.

New Haven, January 1, 1851. B. SILLIMAN, Senior.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XVI.—*On the Velocity of the Galvanic Current in Telegraph Wires;* by B. A. GOULD, Jr., in a Report to Prof. A. D. BACHE, LL.D., Superintendent of the U. S. Coast Survey.

(Concluded from page 89.)

THE remaining questions to which I propose to apply the results of the Washington and St. Louis experiment are—

1st. Whether the stations on the line received the signal pauses successively in their order of distance, and after intervals directly proportionate to their distance from the place where the signal was made.

2d. If the first question be decided in the affirmative,—by what route the signals reached the several stations: whether they were communicated through the earth, as Mr. Walker believes, when the distance between the stations is less by the earth's surface than through the wires, and if so, with what velocity; or whether they uniformly traversed the wires, and if so, with what velocity.

3d. Whether the intensity of the current occasion any appreciable difference in the velocity,* or whether the interposition of a battery between two stations affect the velocity appreciably.

In all the measurements for the determination of velocity, I have used the electrotomes only, and the results are thus entirely independent of the pass-time of the main circuit.

The Pittsburg and St. Louis registers are both very indistinct, owing partly to want of distinctness in the impression of the

* Fechner Repert. ii. 407. Poggendorff, Annalen, lii, p. 497. De la Rive, Archives de l'Electricité, i. 533.

graving tool, and partly to the bad quality of the paper of which the fillet is made. The Pittsburg register is in many places illegible owing to the shortness of the pass. This could be spared with less inconvenience than any one of the others, but it is a very unfortunate circumstance that the St. Louis record, the most important of all, should be so indistinct. It is affected, moreover, with the additional disadvantage, that the motion of the fillet was slow, and the liability to error in measuring thus greatly increased.

The labor of measuring off the intervals on the fillet is great and very tedious, and the average error of reading amounts to some hundredths of a second, although the intervals were mostly measured with dividers and a metallic scale, not with a diagonal scale of horn.†

"All the results adduced depend upon the mean of a great number of readings, more than 5000 measurements of the work of February 4 having been made, in order to obtain them. The probable error has been computed in each case and indicates the extent to which they are reliable. The corresponding minutes are recognized without difficulty by the pencilings made on the fillet at the time by the operators; but the part of the fillet corresponding to the time of winding up the weight, which moved the registering apparatus, was not always noted, an omission which it may readily be supposed has occasioned much annoyance.

To estimate the length of wire between the several stations, ten per cent. has been added to the distances given in the books of reference. This is, I fear, too small an allowance for the sagging and zigzag course of the wires, but may be used in the absence of positive knowledge on the subject, and gives the following distances for the several stations as measured on the wire.

Washington,				
288	Pittsburg,			
622	334	Cincinnati,		
747	459	125	Louisville,	
1045	757	423	289	St. Louis.

The experiments occupied a period of several hours, the Seaton clock graduating the scale, at Seaton-station, Washington City, Pittsburg, Louisville, and St. Louis. The operator at St. Louis gave arbitrary signals by breaking circuit from time to time, at intervals of two or three seconds, which signals were recorded at all the stations. This he did for two successive minutes, twice during the evening. The same was done by the operators at Louisville, Cincinnati, and Pittsburg. Signals were also made at the latter station for ten minutes after the Seaton battery was

† Proc. Amer. Assoc., 1849, p. 189.

removed from the part of the circuit between the clock and the ground, and interposed between the clock and Pittsburg.

The number of measurements used to obtain the mean difference of the registers is so large that the addition or subtraction of fifty consecutive measurements exerts no appreciable influence on the result.

We have seen that when the clock-pauses are made at Washington and the arbitrary signal-pauses at St. Louis, the difference of the interval between the pauses on the registers of the stations corresponds to the time occupied by the current in traversing *twice* the distance between the stations,—the clock-pauses being recorded later and the signal-pauses earlier at the signal station, by the same amount. The same is true of intermediate places, the excess of the recorded interval at the clock-station being greater by an amount equal to twice the distance between the stations whose fillets are compared, divided by the number of miles traversed by the voltaic current in a second.

Let us now consider the effect of a signal not made at a terminal station, but at some intermediate one. For all places beyond this, the two pauses occur later than the corresponding one at the signal-station, by the same interval. So that the decrease of the recorded interval on the registers of the successive stations measures the velocity for twice the distance from Washington, until we reach the station where the signal was given. But for all places beyond this signal-station, the interval remains the same, and its record should be identical with that of the signal-station itself. We are thus enabled to control our estimate of the velocity between the clock and the signal station, by the records made at all the stations beyond.

I find the following to be the mean excesses of the intervals between the signal-pauses and the preceding clock-pauses on the Washington fillet, over those on the fillets at the other stations.

Washington Excesses.

Register.	Signals.			
	P.	C.	L.	St. L.
Pittsburg, ...	0·0295	0·0283	0·0373	0·0451
Cincinnati, ...	·0317	·0752	·0843	·0950
Louisville, ...	·0347	·0750	·1163	·1343
St. Louis, ...	·0455	·0704	·1108	·1451

Confining ourselves at first to the records of the signals made at St. Louis, we find the several registers to indicate the following velocities:

Pittsburg, . .	12772	miles in a second.
Cincinnati, . . .	13095	"
Louisville, . . .	11124	"
St. Louis, ...	14404	"
Mean, . .	12851	

The agreement of these numbers, I consider very satisfactory. It will be observed that the velocity indicated by the St. Louis register is much greater than that derived from the others. Now the distance from Washington to St. Louis is 1046 miles by the wires, but only 742 in a geodetic line; and the question occurs very naturally whether this apparently greater velocity may not be a consequence of the transmission of the signal by the shorter part of the circuit through the ground, rather than along the wires. The distance to Louisville by the wires is 747 miles, and if the signals are transmitted through the ground to St. Louis with the same velocity as through the wire to Louisville, the time of transmission would be the same for both places. The results of measurement in these experiments show that a longer time was required for the signals to reach St. Louis than Louisville; though the greater length of time does not appear to have been proportionate to the greater distance. Those who believe the signals to be transmitted through the earth (when this distance is shorter), explain both these circumstances by assuming, what is very probable, that the velocity in the ground is different from that in the wire. The data of our experiment would furnish everything necessary to decide this question, did the measurements accord sufficiently well with one another. But when it is remembered that we are dealing with such quantities as hundredths and thousandths of a second, measured too by dividers and a metallic scale, on paper of different qualities, whose hygrometric contractions and expansions are not only very great, but unequal,—we cannot expect any very close accordance, in the results of different measurements.

Giving the other data more in detail, and determining the probable errors of the means by the method of least squares, we have,

St. Louis Signals.

Register.	No. obs.	Interval.	Prob. error.	Velocity	Min. limit	Max. limit
P.	37	0^s·0373	0^s·00267	15442	14410	16633
C.	46	0 ·0844	0 ·00148	11748	14494	15012
L.	46	0 ·1163	0 ·00149	12846	12684	13012
St. L.	36	0 ·1108	0 ·00173	13484	13276	13698

Louisville Signals.

Register	No. obs.	Interval.	Prob. error.	Velocity.	Min. limit.	Max. limit
P.	56	0·0451	0·00252	12772	12096	13527
C.	60	0·0950	0·00302	13095	12691	13525
L.	65	0·1513	0·00252	11124	10919	11337
St. L.	61	0·1451	0·00329	14404	14085	14758

Cincinnati Signals.

Register.	No. obs.	Interval.	Prob. error.	Velocity.	Min. limit	Max. limit.
P.	32	0·0283	0·00459	20400	17513	24294
C.	32	0·0752	0·00486	16543	15534	17685
L.	32	0·0750	0·00489	16587	15571	17744
St. L.	26	0·0704	0·00442	17670	16627	18854

Pittsburg Signals.

Register.	No. obs.	Interval	Prob. error.	Velocity	Min. limit.	Max. limit
P.	44	0·0295	0·00154	19525	18557	20601
C.	36	0·0317	0·00233	18170	16926	19612
L.	37	0·0347	0·00258	16591	15451	17922
St. L.	10	0·0405	0·00249	12659	12003	13392

Classifying these according to the stations whose distances are measured by the recorded values.

Stations.	Mean Interval.	No. obs.	Ded'd Velocity.
Pittsburg.....	0·03567	152	16147 miles per second.
Cincinnati.....	0·08289	196	15008
Louisville.....	0·12291	147	12155
St. Louis.....	0·14510	61	14404

The combination of all these, according to the method of least squares, gives, as the result of the experiments of Feb. 4, a velocity of 14900 miles, with a probable error of the mean $= \pm 10$.

These last tables seem to answer conclusively the first of the questions just propounded,—and at the same time to suggest the second. We are justified in assuming that the signals, given by making and breaking the galvanic circuit of the telegraph, reach the several stations successively in their order of distance, and traveling with a finite and measurable velocity. But do they reach the terminal station *through the wires* first, when the distance through the ground is shorter?

Were the arrangement of the telegraph such now as it was at first, one source of uncertainty would perhaps have been avoided in the experiments; but the opportunity of solving this latter problem would have been lost. Until telegraphers availed themselves of the discovery of Steinheil, that no control over the circuit was lost when one half of it was formed by the earth, each telegraph line was double—consisting of one wire to the terminus and another back. But in all the lines in use in this country, the earth forms one half of the circuit. Are we to consider, when the two distant extremities of a line of wire communicate with the earth at a distance of many hundred miles from one another, that there is a special line of tension through the earth from one extremity to the other? and that a signal is communicated from terminus to terminus through the ground, in the same manner as it is through the wire? or may we consider the earth as a huge receptacle, to speak metaphorically, capable of receiving or imparting any amount of electricity at any time? The former opinion is held by my friend Mr. Walker.

But does it not seem improbable that the slight activity of a galvanic battery, traversing a circuit of 1000 miles of wire, should be sufficient to establish a *special* line of electric tension extending through the earth in a cord or parallel with the surface for 750 miles? For my own part, when I remember not only the

grand phenomena of terrestrial magnetism,* but the immense galvanic force which must† be exerted by the mutual influence of the huge masses of metal in the bowels of the earth,—when I consider the mighty electrical activity developed‡ in the great processes of nature,—I will confess that I can not bring myself to believe that *one special continuous line* of electric tension in the ground between two remote stations can be established athwart all these colossal forces by the action of a puny telegraph battery.§ Still, any views must be presented with diffidence, which vary from the expressed opinions of some of the greatest of our scientists.

The view which I take appears to be corroborated by the Coast Survey experiments of Feb. 4, in a two-fold manner.

First, if we suppose the clock-signals, starting simultaneously from the Seaton Station in two directions, to be propagated both through the wires and through the earth to the terminus at St. Louis, we must assume one of two things:—

1. That the signal which traverses the ground, moves with a velocity bearing precisely the same ratio to that through the wire, that the distance by one route bears to the distance by the other. This would be almost infinitely improbable, had we only the St. Louis experiment to guide us. But we have the results of the Coast-Survey experiments to Cincinnati and to Charleston, which prove this hypothesis to be incorrect.

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* Faraday, Researches, ii, p. 151. † Phil. Trans., 1830.

‡ Pouillet, Ann. de Chim. et de Phys., xxxv, p. 414; Becquerel, Traité, iv, pp. 161, 188; Bibliotheque Univ., xiv, pp. 129, 171; Faraday, Researches, ii, pp. 47, 93.

§ I say *special* line of tension, meaning by this a line, whether independent or resultant, which is capable of conveying electrotone and electropea signals in the same manner that a wire conveys them. After the admirable analytical investigations* of Smaasen, and the corroborative though independent researches† of Ridolfi, the character of conduction through the earth can no longer be doubtful. According to Baumgartner's experiments,‡ the earth's resistance to conduction of the voltaic current would appear dependent in great measure upon the geological formation of the localities traversed, as his attempts to measure the earth's conductive power gave very different numerical results in different directions from Vienna. Baumgartner infers from his experiments that the curved lines traversed by the current between the electrodes do not diverge so much as the researches of Smaasen and Kirchhoff‖ would lead us to suppose. But are not his experiments exposed to the criticism, suggested§ by Smaasen, that we must know the precise polarization of the plates before we are warranted in forming any inference as to the earth's resistance. Any attempts to infer the conductive power of the earth from the coast survey experiments of 1849, Jan. 23 or Oct. 31, or of 1850, Feb. 4, Feb. 5, or July 8, by assuming that the earth conducted telegraphic signals, would assign to the earth a smaller conductive power than that of iron wire,—a result in the most direct contradiction to the experiments of Jacobi,** Matteucci,†† and Baumgartner.

But if we assume that the earth can under the most favorable circumstances conduct signals as a wire does, this assumption vitiates the experiments of Mitchel,‡‡ and of Fizeau and Gounelle.§§

* Pogg. Annalen, lxix, p. 162, et seq., lxxii, p. 435.

† Il Cimento, 1847, May, June. v. Pogg. Annalen, lxii, p. 449.

‡ Sitzungsbericht d. Wiener Acad., 1849, May 10, July 5.

‖ Pogg. Annalen, lxxii, p. 497; lxxv, p. 189. § Pogg. Annalen, lxxii, p. 448.

** Pogg. Ann., lxviii, p. 483. †† De la Rive, Archives de l'Electr., xvii, 157.

‡‡ Astr. Jour., i, p. 43. §§ Comptes Rendus, xxx, p. 137.

2. We may suppose the velocity through the earth to be so small, that the electrotome after a passage of 742 miles through the earth has not reached St. Louis until the whole signal-pause and electropœa have been transmitted through the wire 1049 miles. On this theory, the passage of the 742 miles through the ground would occupy more than a quarter of a second, and we can not tell how much more.

The second argument in support of my view is also derived from experiment, and although not consisting of so direct a negation as the first, partakes of the nature of a *reductio ad absurdum* in a sufficient degree to be perhaps yet more convincing than the former. It depends on the comparison of the records of signals made at St. Louis and at the nearer stations.

If we assume that the signals between Washington and St. Louis were transmitted through the earth, it is easy by the comparison of the Louisville and St. Louis fillets to determine the velocity of propagation in the ground. The St. Louis register gives, on the assumption above made, a velocity through the earth which would make the time of transmission for 742 miles between the termini equal to that required for traversing 528 miles of the wire. This amounts to the same thing as if the current between the termini traveled with the same velocity as in the wire, but through a distance of only 528 miles. For convenience of expression, I will speak as though this were the case. The result would be precisely the same.

We have then, on comparing the different registers, two kinds of cases—one in which the distance between the stations is shorter through the wire, and the other in which it is shorter through the ground. We deduce the velocity for the latter instances on each hypothesis—and then inquire which best accords with the velocity computed from those cases where both hypotheses would give the same result.

The following table furnishes the materials for this comparison. The first hypothesis is that the signals traversed the wire alone; the second that they traversed the shorter route through the ground. In one column are the relative distances on each hypothesis;—in the other the deduced velocities. I infer from the discrepancies in the deduced velocities, that the improbability of the second hypothesis is exceedingly great.

Signal.	Register.	Relative Distance.		Corresponding Velocity.	
		Hyp. I.	Hyp. II	Hyp. I.	Hyp. II.
St. L.	P.	576	59	12800	1311
P.	St. L.	576	59	10473	1073
St. L.	C.	1244	727	13097	7651
C.	St. L.	1244	727	17771	10386
St. L.	L.	1494	977	11405	7458
L.	St. L.	1494	977	13484	8817
St. L.	St. L.	2090	1055	14415	7283

All the results of the experiments made by the Coast Survey for the determination of the velocity of the galvanic current, have been most kindly placed at my disposal by my friend Mr. Walker to whom you had confided the entire direction of the work. These furnish the materials for a series of tables, containing the deductions from all the experiments. Collecting in one table all the cases where the current must have passed through the wires, and in another all those instances where the ground furnished part of the shortest circuit, we have two equations with two unknown quantities, viz., the velocity in the ground and in the wires. Determining the latter independently, we find the velocity deduced from all those cases where the distance is shorter through the wire, to be, by twenty-six different comparisons dependent on 768 readings, 15600 miles a second. Substituting this value in the other equation, we obtain the number of miles of wire to which the time of transmission corresponded. These equations may be formed by aid of the method of least squares. The discussion of the results of all the experiments of the Coast Survey, namely, those on the lines from Washington to Cambridge, Washington to Cincinnati, Washington to Charleston, and Boston to New York, show that the assumption of a transmission through the ground, with a constant velocity, does not materially improve the accordance of the observations. Indeed, in the experiments of February 4, the only indication of a transmission through the ground is to be found in the fact, that the velocity derived from the St. Louis observations can be made to accord better with the mean of the other values, by assuming that the signals traveled 1030 miles instead of 1045. The probable error of our estimate of the length of the wire is much greater than this.

The cases depending on 920 measurements, in which the shortest route is through the ground, are twenty-two in number. The velocity deduced, on the assumption that the signals traversed the ground, would be 11,200 miles in a second.

From all these considerations I infer that in the St. Louis and Washington experiments which were, of all that have been made, the most favorable for exhibiting the phenomena,—the signals were in no case transmitted through the ground.

We have thus endeavored to take account, as far as possible, of all the sources of error which cannot be avoided. and to escape all those which can. Our results. obtained from different data, accord so well with one another as to make it appear very improbable that the velocity of the propagation of the electric state produced in the telegraph wires by a galvanic battery is more than 20,000 or less than 12,000 miles per second.

From the combination of all the Coast Survey experiments with the electro-magnetic telegraph I have endeavored to deduce a measure of the velocity which shall be as reliable as the nature

of the case permits. The difference of temperature, at stations so distant from one another, makes it appear unadvisable to introduce any correction for temperature, even were such a refinement of the same order of magnitude with the unavoidable errors of our measurements, and therefore congruous with their character. The temperature was, in all cases, as low as the freezing point—the insulation not being sufficiently perfect at other times to allow communication between very distant stations. The distances used are the following, in miles—ten per cent. having been added as before.

Washington, 172 Philadelphia, 381 209 New York, 850 469 260 Cambridge.	Washington, 74 Harper's Ferry, 165 91 Cumberland, 309 235 144 Wheeling, 578 504 413 269 Cincinnati.

Washington to Cambridge, through the ground, . . 380
Washington to Cincinnati, " " " . . 403

The great length of wire assigned to the part between New York and Philadelphia is a consequence of the distance to which the line ascends the Hudson before finding a crossing-place.

Date.	Terminus.	Velocity.	Prob. error.
1849 Jan. 23,	Cambridge,	18000	150
" Oct. 31,	Cincinnati,	18330	124
1850 Feb. 4,	St. Louis,	14900	10
" Feb. 5,	Charleston,	16856	

The resultant is 15890 *miles per second, as the most probable value.*

Mr. Walker's experiment, 1850, July 8, with the Electro-chemical Telegraph,* gave for the velocity between Boston and New York (220 miles) 13333 miles a second. The wire of Bain's Telegraph is however of a different size from the other lines, and is coated over to prevent oxydation. Should we assume the signals to have been transmitted through the ground, Feb. 5, and July 8, we should obtain the respective velocities 10690 and **10820 miles per second.**

In spite of the mutual confirmation of the several results by one another, and although the accordance is even remarkable, considering the numerous obstacles and sources of error, it is nevertheless true that the observations might be still better represented by supposing the velocity to be different at different parts of the line. Is this assumption admissible? It is, if we have reason to suppose that the velocity is dependent on the intensity of the current—for several batteries were interposed at intermediate stations on the line. The most powerful battery was at Pittsburg, consisting of fifty Grove's cups, each holding a pint. The comparison of the different velocities appears to indicate that

* Ast. Journ., i, p. 105.

the greatest velocity of propagation was between Pittsburg and Washington, and Pittsburg and Cincinnati, but I am not disposed to lay stress on this point. In order to determine whether the velocity of the current was the same, when a battery was interposed between the signal and registering station, Mr. Walker made, as has been said, a special experiment, by continuing the Pittsburg signals for ten minutes after the Washington battery had been changed from between the ground-connection and the clock, to part of the circuit between the clock and Pittsburg. The difference between the times of transmission given in the two cases, is so small as to be practically inappreciable, and probably owing to the unavoidable errors of reading.

Eight measurements on the Pittsburg and Cincinnati registers, where the battery was not interposed, gave as the time of transmission from Washington to Pittsburg 0ˢ·03049. Seventy-four measurements on the same registers when the battery was interposed gave this time of transmission 0ˢ·03106.

Yet this does not furnish an answer to the question, whether the velocity is a function of the intensity of the current; for this intensity can hardly be varied by a transfer of either the circuit-breaker or the recording apparatus to the other side of the battery.

I have taken no account of time requisite for the development of the galvanic current,—inasmuch as, according to the experiments of Jacobi,* this time must certainly be a quantity of the second order when compared with the time requisite for the propagation of the electric force along 1000 miles of iron wire.†

There are several cases in which the line separating the clock-pause from the signal-pause precedes the clock-pause on the St. Louis register and follows the corresponding one on the Washington registers. This was first discovered by Mr. Walker, who considers‡ it to indicate that waves caused by breaking and closing the circuit may travel in opposite directions and cross one another, without interference. This view is theoretically startling to those who have looked on electric phenomena as exhibitions of a polar force, and I have examined with great care all the cases of this kind which could be found. In none of them can I find the distance between the signal-pauses on the two fillets to correspond, even approximately, to the velocity which the comparison of the same fillets indicates. The interval is generally twice as great as would be due to the time of transmission. I have been compelled to look in a very different direction for the explanation of the phenomenon. The St. Louis operator often struck the break-circuit key twice in quick succession; and in the cases under discussion, it would appear that the interval between these two consecutive signal-pauses was very nearly equal to the time

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* Pogg. Ann., xlv, 23.

† Haldat, Comptes Rendus, vi, 52. De la Rive, Arch. de l'Electr., iii, 288.

‡ Proceedings Amer. Assoc., Charleston, 1850, p. 124.

of transmission between St. Louis and Washington, and that one of the signal-pauses was confounded with the clock-pause at St. Louis, and the other with the clock-pause at Washington.

Two circumstances tend to corroborate this view.

1. The length of the clock-pause is in all these cases greater than the average; and

2. The interval between the clock and signal-pauses is neither too great nor too small to correspond with this hypothesis.

There are several other points which I would gladly have discussed; but will however confine myself to the mention of a single curious fact. Reducing the velocity found by Wheatstone for friction-electricity in copper, by multiplying it with the ratio of the conductive power of the two metals, we have 51096 as the corresponding velocity in iron wire of the same diameter (1·75 millimeters), at a temperature of 32° F. This is to the velocity we have deduced, almost precisely in the inverse ratio of the sectional areas of the conducting wires.

It is to be hoped that still farther materials may be collected during the ensuing winter by the zeal of the Superintendent of the Survey, and the indefatigable energy of Mr. Walker. The superior insulating power of the posts in freezing weather, renders winter the most desirable season for instituting experiments of this kind. It is a circumstance in which we as Americans may be warranted in feeling an honest pride that all the telegraph-experiments, excepting those of Mitchel and Fizeau, which have been instituted for deducing the velocity of the galvanic current —a result so important to science, and for the proper discussion of telegraph-observations for longitude—have been made under the superintendence of the U. S. Coast Survey.

In future experiments it appears to me highly desirable that some machinery, capable of delivering several inches of paper per second, at a tolerably uniform rate, should be employed to move the fillet or cylinder on which the record is made; that the quality of the paper used should be as fine as possible. and that the adjustments of the pass and spiral spring should remain unchanged during the continuance of the experiment. Farther experiments with Bain's Chemical Telegraph are desirable, if means can be devised for recording at each extremity of the line, by one and the same circuit, which is not improbable.

The ordinary size of the telegraph wires is, as I understand, that corresponding to a weight of about 300 lbs. to the mile. The new line now constructing, by the patentees of House's wonderful printing telegraph, between Buffalo and New York, is composed of wires weighing from 600 to 800 lbs. to the mile. Experiments made with this line would be of great service in determining whether the velocity varies with the section of the conducting wire.

Very respectfully yours,

Cambridge, August, 1850.

B. A. Gould, Jr.

Art. XVII.—*Observations on the Gnathodon beds around the head of Mobile Bay;* by Rev. C. S. Hale.

The most striking feature of the low, flat region, which forms the northern coast of the Gulf of Mexico, and perhaps the only legitimate one for determining its place in the geological series, are the numerous Gnathodon beds scattered around its bays and deltas.

These remains have long attracted the attention of various individuals, none of whom, however, have favored the public with any results of their observations. Some few years since, an imperfect sketch of what had then been ascertained respecting these beds, was furnished to gratify the desire of a few particular friends. Since then, more extended and satisfactory researches on the subject have been deemed not unworthy of a greater publicity, as a means of extending the boundary of scientific knowledge.

These deposits are not altogether unique in their character: they may be considered as similar in their formation, if not contemporaneous with various others that have been noticed in different parts of the earth; and a reference to some of the latter by way of example, will not be irrelevant to the present design.

The first we shall name, occurs on the coast of Vendée near St. Michael. There are three eminences here, which are entirely composed of marine shells, at a distance of five or six furlongs from the sea, and at an elevation of about five yards above the highest tides. These masses consist of species actually living on the neighboring coast, such as Ostrea edulis, Pecten sanguineus, Murex imbricatus, Buccinum reticulatum.

Another has been observed on the peninsula of St. Hospice, near Nice: it is seventeen yards above the level of the Mediteranean. It consists of calcareous sand, including a large quantity of shells, but little altered, resembling those inhabiting the coast.

A thick bed of marine shells also occurs near Maïta, on a peninsula between the Hellespont and the Gulf of Laros; the species consist of Venus chione and cancellata, Solen vagina, and Cerithium vulgare; the same are still living on the coast. Masses of the same shells may also be seen on the coast of Asia opposite.

Similar instances are known in the island of Great Britain. Adanson makes mention of a large collection of marine shells on the Scottish coast, found near Loch Lomond, seven yards above the level of the sea. Another occurs on the bank of the Forth, likewise another near the Clyde. Each of these beds is elevated about four feet above the tide.

But some of the most remarkable of the shell masses have been observed in Sweden and Norway at an elevation far above the highest tides. The first is at Figa-elo in the northern part of Norway, said to be situated more than one hundred yards above

the level of the sea. Others occur at Tromose and Drontheim, at an elevation of only five or six yards.

Near the small town of Uddevalla, in Sweden, marine shells have been accumulated upon the shore to so great an extent, that from time immemorial they have been carted away for the purpose of paving the public ways. These are at an elevation of about sixty yards; the shells are like those in the neighboring sea; they are almost entirely exempt from earthy mixture.

Near Valparaiso in South America, about forty yards above the level of the ocean, there is a remarkable deposit consisting of a single species, the Concholepas, which is still living on the coast.

Whether the Gnathodon beds in question are to be classed with the preceding remains to be determined.

Of the genus Gnathodon, there are two living species on the American coast, the *Gnathodon cuneata* and *G. flexuosa*, both occurring about the Gulf of Mexico. These are estuary species, and inhabit brackish water; yet there are some apparent exceptions to this statement, owing to the prevalence of fresh water in certain cases; hence the inquiry becomes somewhat important, whether these molluscs can undergo such a change with impunity.

We cannot argue here from animals that are migrating like fishes, to those like mollusca that are stationary. It may be expected that the adaptations of the latter would be as limited as the requirements of the condition in which they are placed; and if this condition be liable to changes, fatal to the welfare of the beings thus situated, this is only of a piece with those contingencies in the general economy of nature, to which all beings are more or less subject in the way of catastrophe involving their destruction. Indeed, I am not aware that there is any known species of mollusc that is adapted to vary its condition in the manner supposed. It was once thought that the Mytilus edulis inhabited the Danube. But a more correct examination has since proved that, so far from being identical with the marine species, it belongs to a different genus (Dreissena).

It is not to be denied that the species, under consideration, is found in circumstances somewhat variable. Belonging to neither extreme, it may undergo a change of medium either more or less salt, or more or less fresh, without much apparent disadvantage. It may even exist for a time in water entirely fresh; still it is contended that no functional change has been produced to render it permanently a fresh-water species. It is more than probable that the deposits far in the interior, are composed of individuals that lived in the vicinity, and were coëval with the formation of those shell masses; and who can doubt their gradual destruction as the sea retreated to its present limits at the head of Mobile bay, where the species are yet found in circumstances congenial to their nature. An instance occurs in Maurepas lake where recent

orographic changes have rendered the water permanently fresh; but it is evident, the few hardy individuals that still live there, cannot long abide the effects of their unnatural situation.

But a more remarkable event in the history of the species is that of their entire destruction north of Florida. This phenomenon, considered as a rare effect of that more remarkable part of the economy of nature which determines the fate of whole species as well as that of individuals, renders this part of our subject particularly interesting. It likewise suggests the importance of more extended observation respecting what relates to the species in this portion of their former geographical range—such as the condition of their remains, and the various other circumstances peculiar to these localities; also the other organisms that may be found imbedded with them;—together with those indications that may be discovered explanatory of the cause of their extinction; whether it be an alteration of climate, or some orographic change affecting the thermal influence of the gulf stream along the coast; or any other agency yet undiscovered.

What has already been ascertained concerning the adaptations of the animal may serve to throw light upon some of the circumstances in which the species is found, whether living or fossil. Their natural adaptation to an exposed situation in the loose mud, furnishes the reason why they are so generally found, either in the sinuosities of the shore, or the cavities of river channels, where the wind and the current may not disturb them. In addition to these considerations, their limited locomotive power, somewhat as in the case of the oyster, will, without the necessity of referring to any other special agency, natural or artificial, sufficiently indicate the cause why such large masses are found precisely in those circumstances, where they are actually presented to our observation.

These deposits will now claim our attention in a geological point of view.

The first consideration regards their position, which occurs in three very distinct varieties of circumstances, answering to as many successive periods in which they were formed. First, the submerged beds; next, those which are only partially submerged; finally, such as are entirely elevated above the water, at various distances from it, and at different elevations.

The submerged beds are not unfrequent around the head of Mobile bay. They have been observed more particularly in Raft river, where they occur in a very regular succession for miles, at a depth of fifteen or twenty feet. The various channels that intersect the extensive morass between the Mobile and Tensaw rivers, seem for the most part to be well adapted to the prosperity of the species in question; at least, this was eminently the case in a more remote period, for here are two of the most remarkable deposits, within the limits of our observation, one for its extraordinary superficial extent, the other for its height.

It is evident however that new masses of shells are still forming in the beds of these streams, in every respect similar to those which are found in elevated situations. These submerged beds also illustrate the method by which the others have been amassed to such a remarkable extent. The living part of the species are frequently liable to perish in becoming too deeply imbedded by an unusual increase of alluvium, a very common event in this delta region; the continued propagation of the species in such circumstances, admits of the continued increase of the mass to an indefinite extent. Superficial marsh-deposits are of no rare occurrence in the vicinity in which the shells are thinly scattered through a thick mass of black mud, clearly evincing that such was the way of their formation. It is not improbable that those elevated masses which occur free from such earthy mixture, existed originally in a similar mixed state, the drifting of the current, or the drenching of the rain, having divested the deposits of the more moveable earthy portion of their ingredients.

The partially submerged state of the next class of deposits, may be ascribed to several different causes. They may have been formed upon an inclined or uneven bottom, so as to have become but partially emerged in the process of their upheaval, or they may originally have been horizontal beds consisting of a large proportion of muddy alluvium, and at the time of their emergence, being but partially exposed to the river current, the earthy portion of the exposed part was washed away, leaving the unmixed shells in a submerged state along the shore. Or finally when the mass was elevated, some individuals may have continued to live and multiply by the shore, forming an apparent continuation of the original deposit.

The submerged portion of these beds may often be traced to a distance of many rods. They occur principally in insular and marshy situations, remote from the main land; particularly on Spanish and Raft rivers and around Grand and Polecat bays. When forming, they must have been at the bottom of a somewhat shallow, but extended bay, which afterwards became silted up, and perhaps partially elevated by means of subterranean action, and was since intersected by numerous rivers and creeks, as well as bays and lagoons, the desirable resort of various species of water fowls, alligators, &c.; and last though not least, of immense quantities of molluscs, the accumulated masses of whose remains are scattered at short intervals over the entire extent of this region.

The third class of beds consists of those which are wholly elevated above the water; they are principally situated on the main land, near the first terrace from the water's edge, at nearly equal elevations above the tide. They are usually of an oblong shape, their longest axis being parallel with the neighboring

shore. They mark the period of the last retreat of the water within its present more circumscribed limits. Their former submerged condition, must evidently have corresponded with that of those which are still found living in a littoral situation. The abrupt termination of these masses, without the appearance of any scattered remains in the interval between them and the shore, likewise the absence of living individuals in the neighboring water, will not seem surprising, when it is considered that the current, caused by the more contracted limits of the channel, must have prevented their continuous multiplication. There are however, some instances, where thinly scattered remains occur even to the water's edge, but such cases are found only in circumstances which are favorable for the continued existence of the species.

The beds of this class are generally two or three yards above the level of the tide. The foundation on which they rest resembles that of a submerged bottom, not that of an open bay,—rather like that of an estuary in the vicinity of rivers and inlets, where the siltings of fresh-water alluviums are not wholly excluded. Those deposits which occur on the Mobile and Tensaw rivers are evidently of a much older date than those already noticed in the intermediate space, which must have remained longer in a condition unfavorable for the propagation of the species.

That series of inland deposits west of Mobile bay, commencing at the northwest angle of that bay near Choctaw point, and extending northwardly to Twenty-one mile bluff, presents several important features; their dimensions manifest a gradual increase in advancing towards their northern limits, where some of the largest and most elevated masses are found; they also mark in a very striking manner, the former inland extent and shore-line of the present bay. It is also observable that the largest of these deposits usually occur near the outlet of some stream, where existed a favorable combination of circumstances for their increase, particularly the confluence of the fresh-water current with the ocean tide. Instances of a similar nature are presented along the borders of that chain of lakes, connecting with the Gulf of Mexico, and extending into the southeast section of Louisiana, especially the one which formerly existed at the mouth of Blind river. it is more than twenty feet high and six hundred yards in length.

Before proceeding to the examination of our last object of inquiry, the structure and contents of these beds, it will be proper to notice the distinction which ought to be made between certain effects of Indian agency, and those which are the result of natural causes.

It is evident that at some former period these shell deposits were objects of much interest to the aborigines. They seem to

have selected them in a special manner, as burying places for their dead—for this and perhaps also for some other reasons, they became places of resort, and the receptacles not only of human remains, but of various kinds of superstitious relics, spoils of hunting, also of various fragments resulting from certain kinds of artificial operations which they found convenient to practice in these places. The different sorts of objects here alluded to, have been distinctly traced, as they occur in the original mass of organic remains.

Human remains are somewhat abundant in certain deposits, but generally in a very broken state. Fragments of pottery are also common; they appear to have been manufactured on the spot, as they are partially composed of pulverized shells. Religious images, formed of the same materials as the former, have also been found to a limited extent. The occurrence of the Cardium, and especially of a large variety of Pyrula perversa, both marine species, inhabiting the gulf, seemed rather surprising, until it was ascertained that the natives make special use of these particular shells for the manufacture of ornaments for the neck. Coal and ashes must also have been produced by their fires; but the latter can seldom be detected, having disappeared by mixing with the shells, and the former is seldom distinguishable from the carbonized wood which abounds.

In regard to the opinion that these masses of shells have been formed entirely by the Indians, nothing can appear more improbable, if the circumstances of their existence are duly considered. It is not to be denied, that, in some instances, the natives might have brought living shells to these places for the purposes of food: indeed, it is highly probable, that those thinly scattered shells that are found near where living ones were easily obtained, may have been entirely the remains of their repasts: for these instances correspond precisely with those which occur in the interior, where the remains of the Unio and Paludina are thinly scattered along the banks of the rivers, but are never found in dense masses.

The following facts selected from many of like nature, may be presented as a refutation of the notion respecting Indian agency in the formation of the beds in question. There are none of the species, of which they are composed, to be found within a long distance of many of the largest of these deposits; and others, not a few, have their foundation several feet below the level of tide water, besides being situated in various other respects quite incompatible with the notion of human intervention, in the affair of their construction—such as partial submergence: the clear proofs of their natural stratification, and especially the general occurrence of immature and minute species, scattered through the mass, all which is quite unaccountable if considered as the effect of Indian labor.

There is a strange disposition manifested by many of our antiquarians to seek for the marvelous in whatever relates to the doings of our aborigines. In certain regions of the country, almost every trace of their former operations is by a hasty induction resolved into some astonishing display of their skill and industry. It is very amusing to witness the extent to which this sort of philosophizing has been carried in some parts of the continent where nature herself has so entirely preoccupied the ground, by throwing up an almost uninterrupted succession of ridges and mounds, as to leave scarcely the possibility for the employment of Indian enterprise in such operations, without encroaching upon her own domain. But through the entire length and breadth of the flat and level plain bordering the Gulf of Mexico, there happens to be no other means at hand for discovering the celebrity of its equally numerous and powerful aboriginal inhabitants, except the masses of shells, which unfortunately in this case can serve only as a proof of gastronomic ability.

A few facts in relation to the structure of these beds may now be noticed. Only the thicker masses, however, possess much importance in this respect; these contain intermixtures of various kinds of earths and other ingredients, indicating more or less clearly the circumstances under which they originated. Reference to a large deposit near the junction of Raft and Tensaw rivers, will furnish the best illustration of this particular, both in regard to its structure and contents, as it combines the principal characteristics of all these beds. It is nearly circular in form; the diameter of its apparent base is one hundred yards, but its real base, which is ten feet deeper, extending out at a distance beneath the soil, is one hundred and forty yards. The most elevated part of the mass, consisting of a ridge forming a chord line near its western limits, is from fifteen to twenty feet above the apparent base. From this ridge the surface gradually declines towards the eastern border where it thins out. The superficial part of the mass consists of shells and a mixture of dark colored earth or vegetable mould; then succeeds a series of strata composed of various ingredients besides the shells, such as sand, calcareous mixtures, several kinds of organic remains, principally those of fish, all of which are so arranged as to exhibit distinct signs of stratification. The following is a perpendicular section in the most elevated part of the deposit. 1. The superficial mass of vegetable mould already noticed. 2. A layer of shells almost free from mixture. 3. Another intermixture of dark earthy matter with shells. 4. Shells mixed with yellowish earthy matter. 5. A thick mass of sand and shells. 6. A thin seam of shells with a dark mixture, succeeded by rotten comminuted ones. 7. A deposit composed principally of very small shells. 8. A seam of dark colored earth, succeeded by another of a yellowish marly

nature, containing a smaller proportion of shells. 9. A thick mass of shells and sand. 10. At this stage, which approaches the level of tide water, a very marked change takes place in the features of the bed; instead of shells, earthy matter now becomes predominant, which here consists of yellowish sand, and other organic remains become less common. 11. Masses of red sandstone and conglomerate in a regular stratum, intermixed with sand and shells; dimension of the masses from the size of the fist to six inches in diameter. 12. Stratum of dark sandy marl, with a continued deficiency of shells and other organic remains. 13. A mass of comminuted shells with a little earth and a few entire well preserved shells. 14. The remainder of the section, extending only to the level of tide water, consists of a mass of well preserved shells, free from every species of mixture, a circumstance attributable to the percolation of the water through the body of shells, which having destroyed the other more perishable remains, became a preserving medium to the shells. This effect is very common in the thinner deposits; being more exposed when in a submerged state to the drifting of the current, and afterwards to the drenching of the rain, they become deprived of their less permanent interstitial ingredients.

A deposit near the mouth of Three Mile Creek, deserves mention in this connection. It is about four feet in thickness, rests upon a sandy base, and consists of a stratified mass of sand and shells. The part bordering upon the creek, which is in a low marshy situation, contains but few shells, imbedded in a deposit of black mud; the valves of many of these are united, and evidently in the position in which they lived; others are actually living in the bed of the creek. The whole presents a very interesting gradation in the series of geological events which have transpired between the remote past and the present time.

The large deposit on the southern terrace of Twenty-one Mile Bluff, furnishes another instance of regular stratification. It is covered with an unusually thick soil over the mass of shells, like that of the surrounding land, which must have been formed previous to the emergence of the original shell-bed above the surface of the water. The earthy alluvium was found to be abundantly diffused through the mass of these remains.

The organic remains that are included in these deposits have no doubt already been understood to consist almost entirely of a single species, the G. cuneatus. Their living characteristics have been noticed: they are now to be considered as fossils. But the various circumstances in which they exist often render the determination of their antiquity very uncertain from the sole examination of the shell. Their decayed state, in the superficial exposed part of a deposit, may give it all the appearance of an ancient formation; while those at the base, with the exception of the

loss of their epidermis, retain all the marks of recent shells. Their normal characteristics are generally to be sought where they are imbedded in earthy mixtures; the determinations of the relative age of those beds that are differently constituted, must depend upon other criteria.

An instance of the former kind is the interesting deposit at Twenty-one Mile Bluff. These remains have continued without disturbance in their alluvial deposit, as they were originally formed, until the present period. They have lost their animal matter, their external surface has become somewhat worn by the wasting influence of time, and a silicious incrustation has been formed in their cavities, exhibiting the appearance of an approximation to a petrified state. From these older deposits an evident gradation in effects of a similar kind may be traced in other masses answerable to the date of their formation as it approaches the present time.

There are also other organisms associated with the former, and though not numerous, they are more or less important as means to illustrate the history of these formations. Among these, the Cyrena of Carolina claims a particular notice; it is an estuary shell, and is usually associated with G. cuneatus, both living and fossil; and in both of these states it occurs in the same apparent numerical proportion. There are, however, some few deposits, especially such as are more elevated, (the one near the junction of Tensaw and Raft rivers is an instance,) in which the Cyrenæ are limited to particular sections; perhaps they are not adapted to every variety of circumstance in which the G. cuneatus may exist.

The Neritina reclivata is another species found in these deposits, but in various proportions in different beds, and in some they are entirely absent. In the one at Twenty-one Mile Bluff, the individuals occur in about the same numerical proportion as those of the G. cuneatus itself, while there are very few to be found in the large deposit, near the junction of Raft and Tensaw rivers. But it is a striking fact that at the present time, living ones abound in the vicinity of the latter, while the former is far beyond the limits of their present habitation. They are usually found living in calm, stagnant situations, attached to water plants and old sunken logs. In a locality of this kind, near Choctaw Point, they may be seen crawling over the bottom where the G. cuneatus still exists.

The few remains of other testacea found in these deposits, such as the Unio and Oyster, must have been introduced by methods more indirect. The former were probably transported from their more interior abode by means of the fresh water currents. But there is evidence that the latter perhaps in some accidental way were to a small extent generated upon the spot.

The residue of these remains belong to terrestrial mammals, birds, fish, and reptiles. The two former, consisting only of a few broken and rather indeterminate fragments in a somewhat superficial situation, may without impropriety be regarded as the spoils of hunting. But the next class, pertaining to fish, were undoubtedly, with very few exceptions, contemporaneous with the formations where they occur. For with the exception perhaps of a small portion of the superior part of the remains in question, they are scattered more or less abundantly through the entire mass in such a manner as to render it evident that they found their way there by no artificial process. For the exuviæ of each animal occur in separate and distinct masses, more or less complete,—scales, vertebræ and all.

In one instance no inconsiderable portion of the vertebral column of a large species was found deposited in a connected form in the interior of one of these shell masses, just as other analogous remains occur in ancient formations when they have not been exposed to disturbing causes.

Some of the species which have been obtained are of more frequent occurrence than others, and these are precisely the kind which might have been expected to be found with these remains, such as the Sargus ovis and an unknown species of Sparus (?). The strong pavement of palatal teeth which these fish possess enables them to feed on the Testacea in question, whose shells they crush with facility. Besides these, species of Perca, Breme, and a few others, are somewhat common; also vertebræ of the Lepisosteus ferox, already alluded to. Teeth of the Alligator Mississippiensis occur in a few instances. Also somewhat numerous remains of several species of Emys. In some of the large deposits, crab's claws have been found. All these, as far as ascertained, appear to be contemporaneous with the existing fauna.

The general absence of organic remains in the remaining portion of the region bordering on the Gulf of Mexico, renders its place in the geological series somewhat uncertain. The only organisms yet discovered consist of casts of Unios, so far as ascertained, belonging also to existing species, such as U. plicatus and circulus, the present inhabitants of our rivers; they were obtained from a locality sixteen miles distant from the head of Mobile bay, in a northwesterly direction, from an excavation made to a depth of thirty feet.

There are also considerable quantities of drifted alluvium, logs, &c., which have been discovered at various depths, both in the recent and more ancient alluvial deposits. But these lead to no very definite conclusion. And the subjacent sands and clays, so far as observed through the whole series, bordering upon the water courses, even to the outcropping of the white limestone, are equally destitute of organic distinctions. It is however very

probable that the sand and mottled clay formation, commencing as it does from the white limestone, was continued up to a period contemporaneous with the formation of the oldest Gnathodon beds, such as that at Twenty-one Mile Bluff, which evidently rests upon the last of the clay series. And from thence we have for data the succession of the shell formation in question, extending through perhaps the post-pliocene and alluvium period, exhibiting a pretty regular series of geological events, even to the present time.

ART. XVIII.—*On the Mineral Springs of Canada;* by T. S. HUNT, Chemist and Mineralogist to the Geological Commission of Canada. No. III.

IN two previous communications to this Journal, I have given descriptions and quantitative analyses of several mineral waters which had been described in the Annual Report of Progress of the Geological Survey of Canada for 1848–1849. The following are a continuation of the same series of researches and appeared in the Annual Report, 1849–1850. For the plan of analysis pursued, I refer to the previous articles which appeared in vol. viii, p. 364, and vol. ix, p. 266.

Varennes Springs.—These sources are upon the southern border of the St. Lawrence, about seventeen miles below Montreal, and rise through strata, which, though concealed by the tertiary clay of the valley, belong either to the upper portion of the Utica slates or the lower beds of the Loraine shales. They are pleasantly situated about a mile and a half below the church of Varennes, at the base of a little ridge which runs along at a small distance from the shore, and bounds a fine tract of meadow land. A century ago they were greatly resorted to, but of late years have fallen into unmerited neglect.

The springs, which are two in number, are very similar in their sensible properties; the outer spring, which is distant about a hundred rods from the house that encloses the other, is the one generally resorted to for drinking, and is called by the villagers by the way of distinction the "Saline," while the spring within the house, from the immense quantity of carburetted hydrogen which it evolves, is known as the "Gas Spring." Within about ten feet from this, is another well, but the water has the same level and temperature as the last, and is said to belong to the same basin.

The water in the outer well is about eight feet deep; it rises quite to the surface and is limpid and slightly sparkling; from

time to time a few bubbles of carburetted hydrogen are evolved. The flow of water from the spring is probably two or three gallons per minute; around the well, there is a slight deposit, ochre yellow on the surface and bluish green within, and the course of the spring is tinged of a yellowish hue for some distance. The water is saline to the taste, and has a very agreeable flavor.

The water of the inner spring is about five feet below the top of the well, which appears to be nearly on a level with that of the one previously described. It is kept in constant ebullition by the escape of large volumes of carburetted hydrogen gas, which is collected by a gasometer and employed for lighting the rooms above. The discharge is apparently about the same as that of the other spring; the water is saline to the taste and closely resembles that of the one before mentioned.

The temperature of the two springs is somewhat different; on the 18th of October, that of the outer well was 47°·5 F., and that of the inner one 45°·5; the air being at the same time 44°. I had before visited these springs on the 20th of November 1847, and found the temperature of the outer one nearly the same as above stated, 47° F., while the inner spring was 40°; the air being 19°. I was informed by the proprietor that the former spring, although not protected from the weather, never freezes to any extent, while the latter, although sheltered by the house, and so much below the surface, is filled with ice in severe weather. The escape of such a quantity of gas, which may be supposed to find its way into the spring below in a greatly condensed state, and be rarified in rising, may help to explain in part this difference: but it is conceived by the villagers that it is affected by the changes of the seasons, and is at the same time warmer in summer, a fact which I have, however, not yet been able to verify by experiment.

I. *The Outer Spring.*—This water has been already described as quite saline to the taste, and analysis shows the presence of a large quantity of common salt, with traces of a salt of potassium. The concentrated water is distinctly alkaline, from the presence of a small quantity of carbonate of soda; the lime and magnesia which are present are also held in solution as carbonates. In addition to these were obtained small quantities of bromine and iodine combined with the alkaline bases; traces of iron, alumina and silica, and the rare bases, baryta and strontia, which have never to my knowledge hitherto been observed in any of the mineral waters of this continent. The specific gravity of the water at 60° F., was determined to be 1008·15, pure water being 1000. One thousand grammes of the water yielded as follows:

	Grammes.		Grammes.
Chlorine, . .	5·777100	Lime, . .	·198240
Bromine, . .	·009790	Magnesia, .	·259190
Iodine, . .	·004512	Protoxyd of iron,	·003000
Soda, . .	5·098500	Alumina, . .	*trace*
Potassa, . .	·077900	Silica, . .	·046500
Baryta, . .	·017500	Carbonic acid, .	·920000
Strontia, . .	·007320		

These ingredients may be combined to give the following composition for 1000 parts of the water:

Chlorid of sodium, . . .	9·42310
" of potassium, . . .	·12340
Bromid of sodium, . . .	·01265
Iodid of sodium, . . .	·00541
Carbonate of soda, . . .	·17050
" of baryta, . . .	·02260
" of strontia, . . .	·01400
" of lime, . . .	·35400
" of magnesia, . .	·54432
" of iron, . . .	·00480
Silica, ...	·04650
Alumina and phosphates, . .	*trace*
Carbonic acid, . . .	·46914
Water, ...	988·80958
	1000·00000

The amount of saline materials present is by calculation 10·721. Direct experiment gave of residue dried at 300° F., 10·526 parts for 1000.

The quantity of carbonic acid in the earthy carbonates is by calculation ·4508 and the whole amount by experiment ·920, so that it is little more than the quantity required to form with them bicarbonates. It equals nearly 23·7 cubic inches in 100.

II. *Inner Spring.*—The same remarks that have been made with reference to the last will apply here; it contains all of the ingredients there mentioned, but with some little variations in their proportions. Its specific gravity at 60° F. is 1007·71.

1000 grammes of it yield the following ingredients:

Chlorine, . .	5·13300	Lime, . .	·19544
Bromine, . .	·00360	Magnesia, . .	·16950
Iodine, . .	·00720	Protoxyd of iron, Alumina,	*trace*
Soda, . . .	4·66480	Silica, . .	·05400
Potash, . .	·02500	Carbonic acid, .	·79200
Baryta, . .	·00960		
Strontia, . .	·00680		

These may be so combined as to give in 1000 parts of the water the following composition:

Chlorid of sodium, . . .	8·42860
" of potassium, . . .	·03820
Bromid of sodium, . . .	·00460
Iodid of sodium, . . .	·00850
Carbonate of soda, . . .	·32606
" of baryta, . . .	·01237
" of strontia, . . .	·00960
" of lime, . . .	·34900
" of magnesia, . . .	·35590
" of iron, . . .	} *trace*
Alumina, . . .	}
Silica, . . .	·05400
Carbonic acid, . . .	·31250
Water, . . .	990·10067
	1000·00000

The calculated amount of solid matters in 1000 parts of water in 9·58683; experiment gave of residue dried at 300° F., 9·420 in 1000. The small portion of carbonic acid, which is not sufficient to form bicarbonates with the earthy bases, is connected with the presence of carbonate of soda, which, as I have shown in the alkaline waters of Caledonia, forms a double salt with the carbonate of magnesia.* The quantities of adventitious gases as carburetted hydrogen, nitrogen and oxygen, which are present in small portions in these waters, were not determined. The amount of the carbonic acid gas equals 15·78 cubic inches in 100.

For the separation and determination of the baryta and strontia the following method was adopted.† Having evaporated several litres to dryness with an acid, to separate the silica, the residue was dissolved in a small quantity of water, mixed with a little dilute sulphuric acid, and allowed to stand for twenty-four hours. At the end of this time the precipitate then formed was collected on a filter, slightly washed, dried and fused with carbonate of soda. The mass thus obtained was treated with water, and the carbonates after being well washed were dissolved in hydrochloric acid, the solution evaporated to dryness, dissolved in a little water, and mixed with a solution of hydrofluosilicic acid, which on standing gave a granular precipitate of the fluosilicid of barium. The filtrate from this (the washings being rejected as holding in solution a little of the baryta salt), gave with a solution of gypsum after some time, a precipitate of sulphate of stron-

* See this Journal, vol. ix, p. 272.

† See Fresenius Quant. Anal., p. 293, *et seq.*

tia. The nature of this was still farther proved by reconverting it into a chlorid, which dissolved readily in strong alcohol, and gave a solution which burned with a carmine red flame.

St. Léon Spring.—This mineral spring is situated in the valley of the Rivière à la Glaise, about a mile from the church of the Parish of St. Léon. It rises through the clays of the region which there rest upon the Trenton limestone. The water of the spring is clear and strongly saline, and is kept in constant ebullition by the escape of large quantities of carburetted hydrogen gas; the discharge from the spring is very considerable; the temperature of the well was found to be 46° F. on the 12th October, the air being 42°. The specific gravity of the water at 60° is 1011·23; its taste is at the same time decidedly saline and ferruginous, and a qualitative analysis showed the presence of chlorids, bromids and iodids of sodium, potassium, calcium and magnesium; minute quantities of barium and strontium were likewise detected, and carbonates of lime and magnesia as usual, with small portions of alumina, carbonate of iron, and silica.

1000 grammes of the water gave on analysis:

Chlorine, .	7·606820	Lime, .	·226240
Bromine, .	·007956	Magnesia, .	·729070
Iodine, .	·004230	Protoxyd of iron,	·009000
Soda, .	6·094400	Alumina, .	·014500
Potash, .	·115800	Silica, .	·086500
Baryta, .	·001360	Carbonic acid,	1·224000
Strontia, .	·001270		

These ingredients may be combined to give the following composition for 1000 parts of water:

Chlorid of sodium, . . .	11·496800
" of potassium, . .	·183200
" of barium, . . .	·001957
" of strontium, . .	·001960
" of calcium, . .	·071870
" of magnesium, . .	·663642
Bromid of magnesium, . .	·009156
Iodid of magnesium, . . .	·004630
Carbonate of lime, . . .	·349320
" of magnesia, . .	·938800
" of iron, . . .	·014500
Alumina, ...	·014500
Silica, ...	·086500
Carbonic acid, . . .	·577400
Water, ...	985·585765
	1000·000000

The amount of solid matters in 1000 parts is by calculation 13·836835; the quantity of carbonic acid above that required to form neutral carbonates, is equal to 29·16 cubic inches in 100.

Caxton Spring.—This spring is situated in the township of Caxton, on the Yamachiche River, about five leagues from the village of Yamachiche. The river here flows between banks of clay, which are often sixty to eighty feet high, and exceedingly abrupt. The underlying formations are not exposed in the vicinity, but the position is probably near the dividing line between the Trenton limestone and the Postdam sandstone. The spring rises in the narrow valley that lies at the foot of the hill, and near the river, but a few feet above its ordinary level. The water, which is remarkably transparent, rises with great force, accompanied with volumes of carburetted hydrogen gas, which keep it constantly in violent ebullition. The discharge of water is very considerable, probably six or eight gallons per minute; the temperature of the well was found on the 25th of October, to be 49°, that of the air being 44°. The specific gravity of the water at 60° F. is 1010·36; it is strongly saline to the taste, but from the smaller portion of earthy chlorids, less bitter than that of St. Léon, which it much resembles. Like that, it contains in addition to these and the usual alkaline chlorids, portions of bromids and iodids and a litle carbonate of iron. No salts of barium or strontium were detected.

1000 grammes of the water afforded:

Chlorine,	7·44689	Magnesia,	·65650
Bromine,	·02956	Iron (peroxyd),	·00360
Iodine,	·00355	Alumina,	·00500
Soda,	6·23900	Silica,	·04795
Potash,	·05050	Carbonic acid,	1·12600
Lime,	·14636		

These may be combined to give the following compounds:

Chlorid of sodium,	11·77500
" of potassium,	·08000
" of calcium,	·05030
" of magnesium,	·37435
Bromid of magnesium,	·03420
Iodid of magnesium,	·00390
Carbonate of lime,	·21600
" of magnesia,	1·05930
" of iron,	·00540
Alumina,	·00500
Silica,	·04795
Carbonic acid,	·48200
Water,	985·86660
	1000·00000

The amount of solid matters in 1000 parts is by calculation 13·6514.

The Plantagenet Spring.—I have never visited this spring which is in the township of Plantagenet, not far from the southern bank of the Ottawa, and rises through clays.

The following analysis was performed upon a quantity of water furnished me by the proprietor of the spring in February, 1849.

The water at 60° F. has a specific gravity of 1009·39; its taste is strongly saline, and more bitter than that of the Caxton spring, just described. Analysis shews the presence of the alkaline and earthy chlorids, with portions of bromine and iodine, besides carbonates of lime and magnesia, with traces of carbonate of iron.

1000 grammes of it gave—

	Grammes.		Grammes.
Chlorine, .	6·96020	Lime, . .	·08736
Bromine, .	·00700	Magnesia, .	·52353
Iodine, .	·00480	Iron, protoxyd, .	·00540
Soda, . .	6·18414	Silica, . .	·07000
Potash, .	·05600	Carbonic acid, undetermined.	

These when combined give the following salts for 1000 parts of the water:

Chlorid of sodium, . . .	11·66600
" of potassium, . . .	·10400
" of calcium, . . .	·13640
" of magnesium, . .	·24522
Bromid of magnesium, . .	·00805
Iodid of magnesium, . . .	·00527
Carbonate of lime, . . .	·03300
" of magnesia, . . .	·89043
" of iron, . . .	·00964
Silica, ...	·07000
	13·16801

The similarity between the last three waters is very close both in the nature and quantity of the ingredients which they contain. It will be observed that that of St. Léon contains, like the sources of Varennes, baryta and strontia, but in much smaller portions: while that of Caxton is distinguished by the large amount of earthy carbonates which it contains. These three springs, with the intermittent of Caledonia, constitute a well defined class of saline waters, which are contrasted with the other sources of Caledonia, and those of Varennes. In the first class, all of the soda and portions of the lime and magnesia exist as chlorids, while in the second, the quantity of chlorine is not sufficient for the alkaline bases, and all the lime and magnesia, with a portion of the soda, exist as carbonates. From the presence of the carbonate of soda these waters are alkaline and will possess different

medicinal powers from the others, which contain chlorids of calcium and magnesium; the medicinal action of these two salts, and especially of the chlorid of calcium, is so well marked that their presence ought not to be disregarded in estimating the therapeutic value of a mineral water; the distinction here drawn is therefore one to which I would call the attention of the medical profession, and it may also be found that the presence of such active agents as the salts of baryta and strontia, imparts peculiar medicinal virtues to the waters of Varennes and St. Léon.

Montreal, May, 1849.

Art. XIX.—*Whirlwinds produced by the Burning of a Cane-Brake;* by Alexander Fisher Olmsted, A.M.—With a Plate.

The plate accompanying this memoir represents some of the more striking phenomena which attended the burning of a cane-brake near Tuscaloosa, Alabama, on the banks of the Black Warrior river. No engraving or painting can fully represent the magnificence or beauty of the scene, as it owed much to the deep color of the flame, and the vast extent of surface over which it swept, as well as the rapid motion and varied changes of the numerous whirlwinds. The sketch exhibits, however, the forms of many of the whirlwinds that occurred during the progress of the fire, besides other objects that gave interest to the scene.

The cane, as is well known, belongs to the order of Grasses (Gramineæ, family Avenaceæ.)* It grows to a height of thirty-five or forty feet,† although but an inch or two in diameter at base, and has a round, hollow stem, with knots every twelve or fourteen inches. At the top there is a head of foliage, brush-like in appearance, made up of long linear leaves. The canes are met with on the banks of all the rivers in the extreme Southern and South-western States, particularly in the States of Alabama, Mississippi, Louisiana, and Texas. The rapidity of their growth is wonderful. It is reported that young plants sometimes increase ten inches in length in a single night, and a large tract of land in a favorable situation will become covered with full grown canes in an incredibly short period. They form dense thickets, the stems often standing but an inch or two apart, although rising thirty-five or forty feet. They thus constitute a barrier impenetrable by man and large animals, and consequently become a refuge for all kinds of small animals. Through the thickets there are occasional passages due to streamlets or some variation of soil. There are occasional large trees here and there in a cane-

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* *Arundinaria macrosperma* of Michaux, *Ludolfia macrosperma* of Willdenow. There is a smaller kind of cane that grows in Georgia and the neighboring states, and forms cane-brakes equally impassable.

† The sugar-cane usually grows from eight to ten feet.

brake, which probably started before the cane covered the land; but almost all other vegetation is excluded. In clearing such land only a few simple tools are employed,—as a carpenter's adze, or an axe, or a heavy kind of hoe called a "cane hoe,"—and a single blow is sufficient to divide the stalk. The laborer grasps the cane with one hand, and, as he cuts it, throws it behind him and passes on. In this way, an acre of land is soon cleared. To prepare it for the plough it is only necessary to fire the cane; as the roots are, for the most part, near the surface, they are consumed at the same time, and the land is then ready for immediate tillage. From the ease with which it is cleared and from the fertility of the soil, (which may be accurately determined by the size of the canes,) cane land is preferred above all others in the region.

The canes lie for a month or six weeks to dry, and then are gathered into heaps and set on fire in several places at once. As soon as the burning begins, the air that is confined in the hollow jointed stalks, and also the watery vapor, expand and burst the canes asunder with a loud report. These explosions occurring from a vast number of canes at the same time produce a continued roar like the discharge of musketry from an immense army, while the flames roll on with great rapidity. No other sound besides this continued roaring is heard in the progress of the fire. This scene therefore differs widely from fires of brush and timber, such as those described in the thirty-sixth volume of the Journal of Science, which produced whirlwinds accompanied by thunder.

The flame advancing over the dry cane presents tints of an intensity and richness incomparably finer than those produced by the combustion of any other kind of wood. No color or combination of colors possessed by the painter can equal it, and it is even unsurpassed by the red of the prismatic spectrum. The tint is best compared to the deepest red of the spectrum. The smoke also was hardly less magnificent as it rolled upwards from the low ground where the fire was raging far above the elevation on which we stood. Its dense, black masses were darker than the darkest thunder cloud. Instead of the light colors of ordinary smoke, a deep dull black characterized the whirlwinds, and the dense volumes of smoke which enveloped the whole scene. On the edge of the fire, the smoke was equally black, but somewhat less dense. This was true also of some of the whirlwinds, particularly those of the form represented by No. 2, while most of the other forms were revolving masses of dense black smoke.

The cane-brake on which this burning took place covered a space of twenty-five acres. It was set on fire at the part most distant from us, and the tract of land being somewhat curved and irregular, the fire was at first hid from our view. The smoke, however, was visible from the commencement, and the roar of a thousand discharges announced its rapid progress. Soon the flame and smoke issued from behind the wood by which it had

been sometime concealed. The heat became intense where we stood, although at a distance of more than two hundred yards from the fire.

Whirlwinds of a great variety of forms began now to be observed in the hottest part of the fire, gradually increasing in size, in number, and in the space over which they prevailed. In this respect they differed from the whirlwinds already alluded to as described in the Journal of Science, where the flame and smoke united in a single column and the energy of the fire was concentrated towards that column.

These whirlwinds at first were on a comparatively small scale, their height not exceeding thirty-five or forty feet. To these succeeded others on a larger scale, until they reached the height of more than two hundred feet, and the flame and smoke which formed their columns were perfectly distinct from the general mass which rose from the fire. Even after the fire had to a great extent gone down, many whirlwinds were formed on the ashes, and continued to form until we left. During the latter part of the time, however, the whirlwinds were, chiefly, those marked 2 and 3 in the plate.

The kinds of whirlwinds that occurred during the progress of the fire may be arranged under four heads.

1. The most common form was that which was stationary over a part of the fire that was hotter than the neighboring portions. This is represented in No. 4. Its base rests on a pile of burning cane, and the air at this part flows in from all sides towards the center. The smoke and flame, however, soon assume a rotary motion in the column above, and the whole expands into the hour-glass form or funnel shape of the common whirlwinds often seen on a small scale.

2. The second variety (No. 2,) has a progressive motion. Its shape almost indicates the mode in which it was formed. These generally occur over the ashes, being produced in the air above, and were therefore like the upper part of No. 4, and like the whirlwinds very often produced by the meeting of currents of air. Some of these emerged from the flames and became invisible. One, however, passed near enough to us to be noticed by its rustling sound and the leaves which it carried up. This was about fifteen or twenty feet high. It moved slowly by us as we stood about three hundred yards from the fire, (having retreated somewhat from our former position.) Towards the latter part of the fire some very large whirlwinds of this form were seen spinning, like tops, over the ashes, from one part of the fire to the other, marking their paths by blowing the ashes and cinders aside and carrying up only the small amount of ashes which was directly under the points of their cones.

3. A very interesting phenomenon occurred in some of the whirlwinds which is represented in No. 5. This whirlwind is

formed on a pile of burning cane. The flame rolls up into a column where it is extinguished and is succeeded by a dark interval of smoke. Above, and towards the top, the flame breaks out anew. The dark interval is not uniform, but sometimes diminishes almost to a line, and then expands upwards till it covers and extinguishes all the upper portions of the flame. This phenomenon might have been owing to a difference of velocity in the different parts of the whirlwind. The greatest velocity was in the dark interval, and the flame was extinguished in this part on the same principle that a gas jet burns high above, but not on its orifice when a powerful stream of gas is supplied. The gas in this case, by its concentrated form and rapid motion, is not brought into contact with the oxygen of the air sufficiently until it reaches a certain height above the orifice. In the same way the combustible gases of the whirlwind, by their rapid motion and concentrated form in the middle portion of the whirl, do not take fire until they expand above and are mingled more fully with the atmospheric air. The velocity of the whirlwinds would, doubtless, vary continually more or less, and this would account for the continued variation in the size of the dark interval, sometimes diminishing to a line or disappearing when the whirlwind moved comparatively slow, and then expanding with the increased velocity of rotation until all the flame of the upper part was extinguished, and a cone of smoke rested on the base of flame.

4. The whirlwinds of the 4th kind (Nos. 3, 3,) were remarkable for being entirely destitute of the funnel form, for their small diameter, and for their immense height, which was often several hundred feet as indicated by the smoke, and was probably prolonged into the transparent air above. It is a fact of great interest that even in these tall cylindrical whirlwinds, the rotary motion was perfectly obvious throughout their entire length, rolling the black smoke in wreaths like carded wool to the top of the visible column, and probably beyond, as we may infer from their rapid motion.* Towards the top, these whirlwinds were sometimes bent by the wind. This change of direction was more sudden or abrupt than is represented in the plate, and the whirl-

* Some remarks by Mr. Redfield on the whirlwinds already alluded to are peculiarly applicable to this form. "The ascending power of the vertical column or whirlwind is, in these cases, strongly exhibited. We observe that the heated air from large fires, or even from the most powerful furnaces, ejected in a column at the heat of melted iron, will ascend only to a comparatively short distance from the earth; the ascending force being lost in the counter movements and convolutions with the adjacent colder air and the combined product soon spreads off in a horizontal direction. But the spire of a columnar vortex exhibits a penetrating and ascending power which far exceeds both in intensity and extent of action, any other ascending movement that we witness in the atmosphere. The effect appears to be owing to the spiral motion of the column, which presses onward in the direction of its axis, until it reaches a limit of elevation which is yet unknown. Even the *ring vortex*, which is sometimes seen to form at the muzzles of cannon or the ejection pipes of high pressure steam engines, appears to possess the qualities of a projectile, notwithstanding its unfavorable form."

wind was continued notwithstanding the change in its direction. Some were bent into a direction nearly or quite horizontal still revolving rapidly, others were less inclined, and others were cut off on a level with the general mass of smoke or prolonged into the transparent air above.

In connection with the whirlwinds several other facts of interest may be mentioned which occurred during the burning of the cane.

1. The direction of the wind was changed. Being at first from the northeast, it continued in that direction in the upper part of the atmosphere, as was evident from the way in which the columns of smoke were bent. But shortly after the commencement of the burning, the air beneath blew in all directions towards the center of the fire. The columns of smoke rising nearly straight for more than two hundred yards, and being then quite suddenly bent, served to indicate accurately where the general northeast wind prevailed over the currents that surrounded the fire. The influence of the fire may therefore be considered as having extended more than two hundred yards* in height, and over an area of more than three hundred yards around, for at this distance the air blew strongly towards the fire.

2. The entire influence of the fire appeared to be expended on the air in its vicinity, and to produce no effect on the general state of the atmosphere, either at the time or subsequently. This fact is the more important as storms in the region where this fire occurred. particularly thunder storms, are much more frequent and violent than in the Northern States.

3. The whole mass of the air, after entering the area above the fire, exhibited a tendency to rotary motion, being full of eddies and whirlwinds.

4. These whirlwinds revolved on their axes from right to left, and from left to right, without any prevailing tendency to one direction more than to the other. Frequently the same whirlwind would change the direction in which it revolved and would return to its first course. In a few instances this was repeated several times. In no instance, however, was this repeated change of rotation observed in the whirlwinds of the form represented in No. 2, and from this it was evident that this change was owing to a change in the form of the base, as the fire burned down the pile of cane on which the whirlwind was formed. The nicely balanced columns of air ascending in the whirlwind would commence rotation in either direction by a slight inequality in the fire on one side of the base, and would change their rotation when this inequality was from some cause shifted to another part.

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* Probably more than three hundred yards—there was no object with which to estimate these columns except a few scattering trees in the fire.

5. As the fire spread rapidly from different points, it was at length circular in outline, or approached this form. It was not until the heated air was rising from this circle that the whirlwinds became frequent in number or of great size. The same phenomena are shown on a small scale in the common process of putting tire on wheels, where the whole body of air and smoke above the fire appears full of eddies and whirls. If these fires are made in a yard surrounded by high buildings, the effect is greatly increased. In some situations of this kind, whirlwinds of quite regular forms and fifteen or twenty feet high, are sometimes seen. But owing to the dry wood of which these fires are usually formed, and the very small amount of light colored smoke which is produced by this wood, it is generally difficult to determine the exact forms which the whirls assume; yet at different times all the kinds described in this article have been observed.

These facts have a bearing upon the method which has been proposed of producing rain by circular fires. It has been maintained that if a circular fire were created the air would be made to ascend in a single column, a cloud would be formed in the upper part of this column or at the top, and this cloud being thus formed, would subsequently produce rain. The whole theory, therefore, depends upon the first supposition that the air would ascend in a single column; but from the phenomena which attended the burning of the cane-brake, I have been led to the conclusion, that, unless the mass of combustibles were very great, and the fire very intense, no single column of rarefied air, in the majority of cases, would be formed, and, consequently, the phenomena dependent (as it is maintained) upon this supposition would not take place. The great heat produced by the burning of the canes appears, from the fact that we were obliged to move from a station within two hundred yards of the fire to one distant about three hundred yards, and even at this distance the heat of the fire was so strong that most of the company present were at a distance still greater. In all the cases mentioned in the Journal of Science, the mass of combustible matter was very great, and, in one case at least, was piled up towards the center.

6. The location of the cane-brake was very favorable to the formation of whirlwinds, being a river bank, to a great extent surrounded by woods and higher land. It corresponded in some degree to the fires for putting tire on wheels when these are kindled in an inclosure partly surrounded by buildings. I have been informed that the whole air of a large space thus inclosed is sometimes affected by these fires and put in motion in a direction opposite to the general course of the wind. A rotary motion sometimes pervades the air of these places.

7. In the midst of the fire the foliage of the trees (No. 6,) became gradually dried and parched, and finally caught on fire, burning almost with a flash like powder, and adding greatly to the

splendor of the scene. By contrast with the deep-red flame of the canes, the flame of these trees appeared of a very light-red color, and the white smoke of the burning trunks was also in lively contrast with the heavy rolling masses of black smoke which surrounded the fire.

8. The charred leaves of the cane being thin and light were driven off in considerable quantities. They were frequently carried up and were sometimes found at a distance from the place of the fire. Compared, however, with the extent of the fire, and the immense amount of matter consumed, very little was carried off in this manner. The combustion was complete as well as rapid, owing to the dryness of the material, the thinness of the stems and stalks of which it consisted, and the speedy explosion of the hollow joints on the first approach of the fire. Moreover neither the lighter nor heavier parts could rise unconsumed to a great height through the hot air and flame which were above the fire.

These are some of the principal facts which attended this burning. It is a scene of not very common occurrence even at the South, and when it does take place, a few circumstances may entirely change the effect. If, for example, the cane is not sufficiently dry, or if it has been covered with sediment from an overflow of the river on the banks of which it grows, the effect will be changed either in the color of the flame, the rapidity of the fire, or the production of whirlwinds. We were, however, assured that the phenomena we witnessed were such as usually attended the burning of a cane-brake when whirlwinds are produced, though sometimes they occur on a larger scale and in a more striking manner.

ART. XX.—*Description of a new Graptolite found in the lower Silurian Rocks near the Falls of St. Croix River;* by H. A. PROUT, M.D.

THE remains of Graptolites are generally found in so imperfect a state of preservation that their exact place in the scale of animal existence has been a subject of controversy. Some authors have been disposed to refer them to the vegetable world, while others have compared them to some of the lower forms of animal life. Among those who have established a place for them in the *zoological* series we find again some diversity of opinion. Wahlenberg and Schlotheim refer them to the Orthocerata; Nilsson to the Fixed Corticate zoophytes (Gorgonidæ or Antipathidæ); Dr. Beck, of Copenhagen, Murchison, Mantell, Hall and others, to the Pennatulidæ, while other eminent writers have been disposed to place them in the tribe of Sertularia, in the family of Tubularidæ.

When we compare the analogies in the organization of the Gorgonidæ, the Virgulariæ, and the Sertulariæ, this difference of opinion, in regard to the true place of the Graptolites, may, in some measure, be explained. The Gorgonidæ and Pennatulidæ have a long semi-calcareous or horny axis enveloped in a fleshy or coriaceous covering: the Polypi are inserted in, or rather constitute, this cortical envelope, which forms a common bond of association, and have no articulation with the central axis. In the Sertularia on the contrary, the corneous, or hard portion of the polyparium, is external—the axis is traversed by a fluid or gelatinous substance—the cup-like cells or denticles pertaining to the polypi are tubular and have a connection with the material which occupies the interior.

In the relative changes which would materially take place after the death of these Polypi, it suggests itself to us that the more corneous or calcareous portion would be least liable to decay, and consequently more subject to fossilization, while the gelatinous or fleshy part would be subject to rapid decomposition.

It is well known that a destruction of the cortical covering as well as the horny or calcareous axis very frequently occurs, and the imperfect impressions which they leave, impart some uncertainty to the distinctions which have been founded upon them. Moreover it is obvious that according to the position of the Polypi on the polyparium at the time of extinction, or the relative position of the setæ to the surface of the rock, when subsequently brought to light, some variation in the appearance of the same species may give rise to unnecessary distinctions in an attempt at a regular classification of these bodies.

Dr. Beck gives to Graptolites the following generic characters:

"Polyparium—indivisum, elongatum, sublineare, acuminatum, obtusiusculum, statu fossili compressissimum serratum."

"Polypi alternantes cum tubulo communi centrali communicantes in fossili statu sæpissime secati rarius bifarii oblongi acuminati."*

It is obvious that the clause, "cum tubulo communi centrali communicantes," implies that the polyparium and the denticles are both tubular. The axis, in most of those which we have seen described, is represented as being capillary while it is not stated whether they are solid or tubular, or whether the setæ or dissepiments are tubular or clasping. With due deference to the opinion of Dr. Beck and others, I am inclined to believe that the species which I shall presently describe, and perhaps all others characterized by a hollow central tube and tubular cells for the reception of the Polypi, more probably owe their origin to the tribe of Sertularia than to Virgularia—for we have seen

* Murchison's Silurian System, p. 695.

that the tubes of the Polypi, in the Virgulariæ and Gorgonidæ have no regular connection with the central axis except through the medium of a fleshy or coriaceous envelop, and in the fossil state it is difficult to account for a tubular appearance or a regular connection between the receptacles of the Polypi, (which in Virgularia are mere setæ,) and a common central tube, unless we suppose the entire destruction of the central or semicalcareous stem, while the softer and more destructible fleshy envelop remained in a perfect state of preservation. We should much sooner anticipate a destruction of the cortical substance than the harder and more durable axial support. We know that this relative change does take place in the living genus of Antipathes, while in the Gorgoniæ, the central axis and the cortical portion are both preserved, but only in virtue of the calcareous matter which enters into the constitution of the cortex. The axis being preserved in both these genera, while the cortical substance in one is subject to decay, renders it probable, I may say certain, that the central stem is in general the most indestructible portion of the zoophyte.

We have been led to this course of reflection by the absence, in the specimen which we are about to describe, of any central axis or stem, and the general tubular structure of the polyparium.

In it, the cup-like denticles are inserted into a common connecting tube, are unilateral and vaginated on their external sides, the side of one cup supporting the next one above it in the series, in which last feature it much resembles some of the living forms of Sertularidæ.

From the appearance manifested in this specimen, we are inclined to infer that Sertularidæ existed at the same time with Pennatulidæ in the ancient seas, and that on a more critical examination of the subject, some of the differences of opinion upon the origin of the Graptolites may be found more seeming than real.

The species of Graptolites which we have discovered differ materially from those figured by Murchison or Hall. We have not seen the monograph of Dr. Beck, but presume if he had described the species, it would have been frequently referred to, not less on account of its structure than the elegance of its form. We shall therefore describe it as a new species, giving it at the same time the name of Graptolithus Hallianus, after Professor Hall, whose labors in the field of American Palæontology so justly entitle him to this honor.

Graptolithus Hallianus.

Polyparium hollow, well defined, branching in a graceful raceme, much branched, branches mostly on one side, never opposite, with unilateral cells, each supporting the next one above it, no solid axis or stype.

Polyp-cells.—To the naked eye the cells appear closely serried, not appressed, transversely serrated; but under a magnifying glass, they appear vaginated, hollow, having a connection with a common central tube, conical with point of cone downwards, sometimes having a faint appearance of a mucronate point on the outer lip, and two longitudinal lateral ribs, extending from the base to the terminal border.

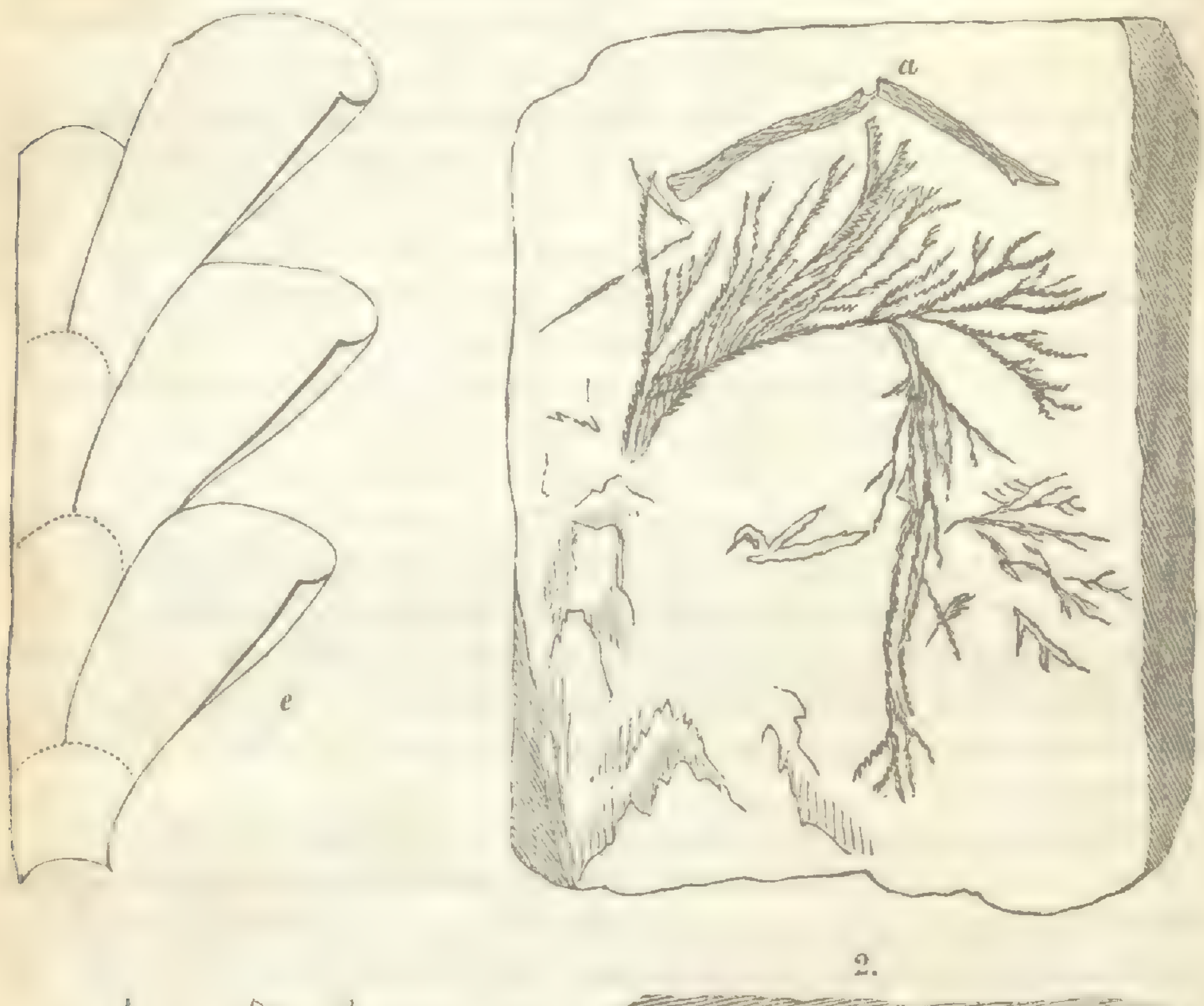


Fig. 1. Graptolithus Hallianus, natural size. Fig. 2. Same, showing the structure more definitely.—*a* (fig. 1), large Graptolite of another species; *b*, a branch nearly natural size; *c*, *d*, magnified; *e*, diagram of supposed structure; *f*, diagram of cell.

This species, which has some general resemblance to the Graptolithus gracilis of Professor Hall, differs in being much more branched, more closely serrated, with serratures not appressed, hollow, conical, and connected with a central tube, instead of a slender stype.

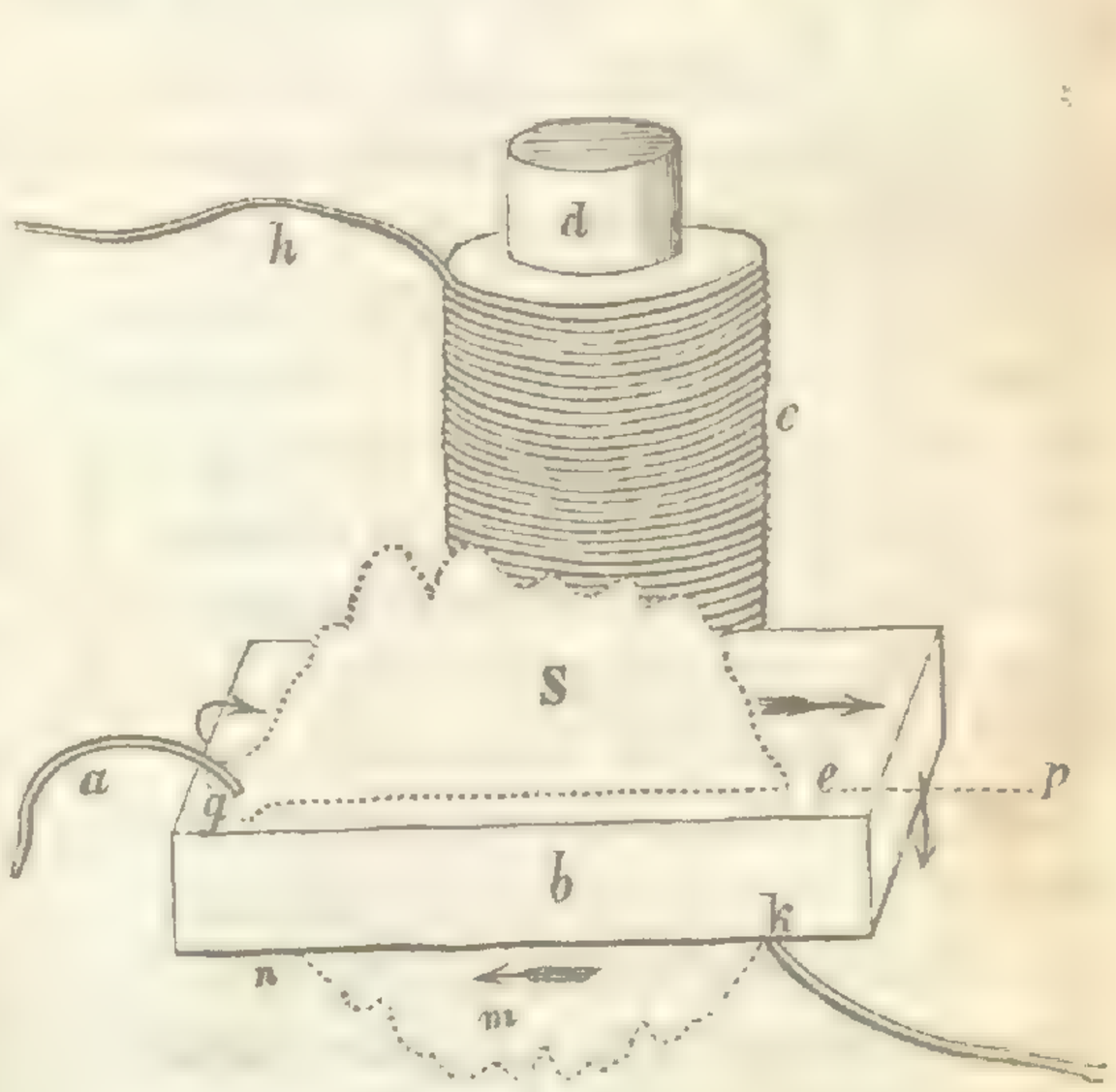
The larger Graptolite marked *a* on figure 1, seems to have belonged to another species, its marking is somewhat indistinct under a high magnifying power, but it seems to be covered with close set setæ much appressed and verticillate in their general arrangement. To the naked eye it appears to be longitudinally wrinkled.

Position and locality—Osceola Mills, near the falls of St. Croix River, in a thin seam of calcareo-aluminous shale, fifty feet above the water level.

ART. XXI.—*On the direction of the Spark from Secondary Currents under the influence of Helices or Magnets;* by Prof. CHAS. G. PAGE, M.D., Washington, D. C.

IN the course of my experiments, recently communicated, in which secondary sparks were obtained from two to six inches in length, the spark seemed to have *direction*, and in the operation of the electro-magnetic engine this peculiar property of the spark was occasionally annoying from the fact of its running along and oxydating metallic surfaces which were intended to be kept clean and bright. On investigating this matter, I found the spark to be subject to the same tangential or rotative action as the conductor itself.

Let *a*, represent one pole of the battery, *b*, a block of copper in connection with one termination of the helix *c*, *h*, the other pole of the battery in connection with the other end of the helix. *d*, the magnet within the helix, and *g* the first point of contact with the copper block. When the maximum of current is reached which is about a second after contact is made, and the current then broken, a dense spark or flame, S, about one inch in height is directed along the surface of the block from *g* to *e*. The lower line of the spark or that portion on the surface

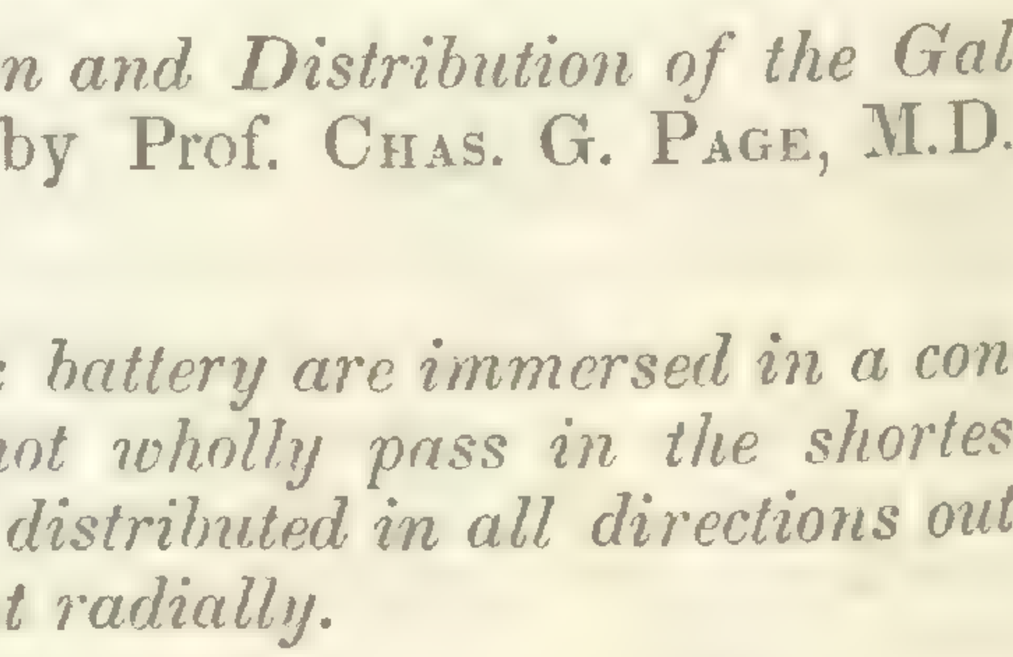


of the block is broken up into brilliant points and dashes. When the wire is placed underneath the block, as at *k*, the spark is impelled in a contrary direction, or from *k* to *n*. If the current is broken at *e*, and the wire drawn suddenly over the end of the block in the direction of *e p*, the spark follows the same direction running off in a brilliant line of light several inches in length. From the direction of the spark above, below and on the ends of the block as shown by the arrows, it appears that the spark or secondary current obeys the same rotative action as does the conductor itself. In arranging the breaks or cut-off in the electro-magnetic engine, it is obvious that this discovery has an important practical bearing, and it will also be important to attend to this point in experiments made with a view to obtain the greatest length of secondary spark. If the position of the block be varied in the experiment so as to place it above the coil, the direction of the spark will be reversed. The influence of the coil in directing the spark was perceived even when the current was broken three feet from the coil.

ART. XXII.—*On the Conduction and Distribution of the Galvanic Current in Liquids;* by Prof. CHAS. G. PAGE, M.D., Washington, D. C.

When the poles of a galvanic battery are immersed in a conducting liquid the current does not wholly pass in the shortest distance between the poles but is distributed in all directions outward and to a considerable extent radially.

Thus if a large plate or dish A, is filled with acidulated water and we immerse in it the poles P N of a galvanic battery the current will be found to have the direction generally of the arrows, 1, 2, 3, at those points. On communicating this fact several years since to Prof. Henry, he informed me that he had noticed it some years before, but that his mode of illustration was quite different from mine. The design therefore of this communication is only to describe my own method and results, some of which are quite novel. The little oval figures, *d*, *d*, represent globules of mercury in the acidulated water and their condition



while the current is passing. The mercury for this purpose must be *very pure*. Before the current is established, the globule of mercury has its usual spherical form, but as soon as the current flows, the globule immediately elongates and moves rapidly towards the negative pole of the battery. This movement takes place when the globule of mercury is at a very considerable distance from the wire, and with very pure mercury it will move up an inclined side of the dish. This curious movement or propulsion appears to be caused by the development of gas about the negative end of the globule. One half of the globule becomes clouded and the other half remains clear and bright. The clouded half is turned towards the positive pole. In the figure, *d*, *d*, exhibit the appearance of the globules, and P, N, the positive and negative poles of the battery, which in this case are platinum wires. Bits of platinum wire laid in the dish as at *b*, give off gases at their extremities, but a peculiar advantage comes from using the globule of mercury, as it elongates and turns itself at once in the direction of the current passing through it. In the figure, quite a number of these globules are represented nearly in the positions assumed in the experiment. When the negative pole is brought directly over a globule of some size, say from $\frac{1}{4}$ to $\frac{1}{2}$ inch diameter, it is thrown into a violent agitation and has a kind of rotary movement from its rapid elongation in every possible direction. Occasionally the globule takes the form as seen at *e*, the larger portion being towards the negative pole, and in this case both ends of the globule are bright, the clouded portion being at *c*, *c*, and here there appeared two little vortices, each having a most rapid whirl.

If now some impure mercury containing zinc be introduced in place of the pure, a singular and reverse condition follows. The end of the globule which was before clouded, becomes clear, and *vice versa*. The movements are less active from greater friction, and also from what appears to be a constrained condition of the polar properties of the globule. The propulsion also of the globule is in the reverse direction, and from the negative to the positive pole, and sluggish in comparison with the motion of a globule of pure mercury. This contrary movement and state of the globule is not easily explained. It occurred to me that the zinc contained in the mercury was detained on the oxygen or positive end of the globule and the mercury as it were filtered out from it. If this supposition be correct, the hydrogen developed at the positive end of the globule by local action, might account for the contrary propulsion and reversal of the whole aspect of the globule. This solution does not however seem to be wholly satisfactory.

Washington, D. C., Dec. 4, 1850.

ART. XXIII.—*Two Problems by Bāpu Deva Shāstri*, Native Professor of Mathematics in the Benares College.* (Communicated for this Journal by Mr. B. H. HALL, and transmitted to this country by Prof. FITZ-EDWARD HALL, of the College of Benares.)

PROBLEM I.

GIVEN an arc and its chord to find the sagitta.

Let A = the given arc, and B = the given chord.

Also let a be an arc similar to A having a rad = 1.

$$\text{Then } \frac{A}{B} = \frac{a}{\text{ch.}a} = \frac{a}{a - \frac{a^3}{2^3.3} + \frac{a^5}{2^5.3.4.5} - \&c.} \text{ (Dif. Cal.)} = m$$

$$\therefore m = \frac{1}{1 - \frac{a^2}{2^3.3} + \frac{a^4}{2^5.3.4.5} - \&c.} = \frac{1}{1 - Aa^2 + Ba^4 - Ca^6 + \&c.}$$

$$\therefore \frac{1}{m} = 1 - Aa^2 + Ba^4 - Ca^6 + \&c.$$

$$\therefore \text{By trans. } Aa^2 - Ba^4 + Ca^6 - Da^8 + \&c. = 1 - \frac{1}{m} = \frac{m-1}{m}.$$

$$\text{Let } n = \frac{m-1}{m} = \frac{\frac{A}{B} - 1}{\frac{A}{B}} = \frac{A-B}{A}$$

$$\text{Then } n = Aa^2 - Ba^4 + Ca^6 - Da^8 + \&c.$$

$\therefore$ By reversion of the series,

$$a^2 = \frac{n}{A} + \frac{Bn^2}{A^3} + \frac{(2B^2 - AC)n^3}{A^5} + \frac{(5B^3 - 5ABC + A^2D)n^4}{A^7} + \&c.$$

$$\text{Again, sagitta of } a = \frac{a^2}{2^3} - \frac{a^4}{2^5.3.4} + \frac{a^6}{2^7.3.4.5.6} - \&c. \text{ (Dif. Cal.)}$$

$$= 3Aa^2 - 5Ba^4 + 7Ca^6 - \&c. \text{ (By subtrn.)}$$

$$= 3n + \frac{3Bn^2}{A^2} + \frac{3(2B^2 - AC)n^3}{A^4} + \frac{3(5B^3 - 5ABC + A^2D)n^4}{A^6} + \&c.$$

$$- \frac{5Bn^2}{A^3} - \frac{10B^2n^3}{A^4} - \frac{(20B^3 - 20ABC)n^4}{A^6} - \&c.$$

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* The principal interest connected with these demonstrations arises from their being an example of the mathematical science of India.—EDS.

$$-\frac{5B^3n^4}{A^6}+\&c. \qquad +\frac{7ACn^3}{A^4}+\frac{21ABCn^4}{A^6}+\&c.$$

$$-\frac{9A^2Dn^4}{A^6}+\&c.$$

$$=3n-\frac{2Bn^2}{A^2}+\frac{4(AC-B^2)n^3}{A^4}-\frac{2(5B^3-13ABC+3A^2D)n^4}{A^6}+\&c.$$

But $a^2=\frac{n}{A}+\frac{Bn^2}{A^3}+\frac{(2B^2-AC)n^3}{A^5}+\frac{(5B^3-5ABC+A^2D)n^4}{A^7}+\dots$

$A=\frac{1}{2^3.2}$, $B=\frac{1}{2^5.2.4.5}$, $C=\frac{1}{2^7.3.4.5.6.7}$, $D=\frac{1}{2^9.3.4.5.6.7.8.9}$

$\therefore$ by subtrn., $a^2=24n+\frac{36}{5}n^2+\frac{387}{175}n^3+\frac{312}{175}n^4+\&c.$ (1)

$$=6n(4+\frac{6}{5}n+\frac{129}{350}n^2+\frac{52}{175}n^3+\&c.)$$

And sagitta of $a=3n-\frac{3}{5}n^2-\frac{33}{175}n^3+\frac{3}{70}n^4+\&c.$

And by extr. the sq. root of (1) $a=\sqrt{6n}(2+\frac{3}{10}n+\frac{39}{560}n^2+\frac{143}{2240}n^3+\&c.)$

Now a : sagitta of a :: A : sagitta of A

$$\therefore \text{sagitta of A}=\frac{\text{A}\times\text{sagitta of } a}{a}$$

$$=\frac{A}{\sqrt{6n}}\cdot\frac{3n-\frac{3}{5}n^2-\frac{33}{175}n^3+\frac{3}{70}n^4+\&c.}{2+\frac{3}{10}n+\frac{39}{560}n^2+\frac{143}{2240}n^3+\&c.}$$

$$=A\sqrt{6n}.\frac{\frac{1}{2}-\frac{1}{10}n-\frac{11}{350}n^2+\frac{1}{140}n^3+\&c.}{2+\frac{3}{10}n+\frac{39}{560}n^2+\frac{147}{2240}n^3+\&c.}$$

$$=A\sqrt{6n}\left(\frac{1}{4}-\frac{7}{80}n-\frac{253}{22400}n^2+\frac{149}{448000}n^3+\&c.\right)$$

Example. Given the arc $=9$ and the chord $=8$ } to find the sagitta.

Here $A=9$, $B=8$, and $\therefore n=\frac{1}{9}$

Then the sagitta of $A = A\sqrt{6n}\left(\frac{1}{4} - \frac{7}{80}n - \frac{253}{22400}n^2 + \frac{149}{448000}n^3 + \&c.\right)$

$$= 9\sqrt{6 . \frac{1}{9} . \left(\frac{1}{4} - \&c.\right)}$$

$$= 3\sqrt{6}(.24014)$$

$$= 3 \times 2{\cdot}44949 \times {\cdot}24014$$

$$= 1{\cdot}76466 = 1\frac{3}{4} \text{ nearly.}$$

Problem II.*

Given an arc and its chord to find the sagitta.

Rule.—Multiply the given arc by 100,000 and divide the product by the given chord. Diminish the quotient by the nearest tabular quotient in col. 4 and set down the difference. (a)

2. Take the said tabular quotient from the one immediately following it, and similarly find the difference of the corresponding tabular chords and sagitta.

3. Multiply the difference (a) by the 2nd and 3d of the three last mentioned differences respectively, and divide the products by the first.

4. Increase these quotients respectively, by the tabular chords and sagitta which have been made subtrahends (§ 2.) Multiply the 2d sum by the given chord and divide the product by the 1st, and the result is the value of the sagitta required.

Similarly the chord may be determined when the arc and the sagitta are given. But in making the calculation the chord is to be considered as the sagitta and vice versa.

Also when the tabular difference (§ 2.) is not less than the one immediately following it, it must be subtracted from that immediately preceding it. And in (§ 4.) the quotients are to be subtracted from the minuends.

Dem.—The ratios of similar arcs and their chords being equal, 100,000 times† the ratios of arcs and their chords are easily found and set down in tables. Opposite to these the chords of similar arcs and their sagittas are also given. Hence the value of any sagitta may be easily determined by simple proportion.

A similar demonstration will apply to the rule for determining the chord, when the arc and its sagitta are given.

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* This Problem is printed in the Benares Recorder.

† The ratios have been multiplied by 100,000 in order to avoid fractions.

Chords.	Sagitta.	Arcs.	Chord.	Sagitta.
10467	137	10472	100046	7643796
20906	548	20944	100183	3821898
31287	1231	31416	100413	2552072
41582	2185	41888	100735	1964066
51764	3407	52360	101152	1536836
61803	4894	62832	101664	1285901
71674	6642	73304	102275	1103643
81347	8645	83776	102986	969069
90798	10899	94248	103800	864739
100000	13397	104720	104720	783160
108928	16133	115192	105753	713395
117557	19098	125664	106890	657996
125864	22285	136136	108174	615239
133826	25646	146608	109551	571660
141721	29289	157080	110838	536311
148629	33087	167552	112733	506899
155429	37068	178024	114537	480263
161803	41221	188496	116498	457259
167734	45536	198968	118622	436990
173205	50000	209440	120920	418880
178201	54601	219912	123407	402762
182709	59326	230384	126094	388335
186716	64163	240856	129103	375381
190211	69098	251328	132132	363727
193185	74118	261800	135518	353229
195629	79209	272272	139177	343738
197538	84357	282744	143134	335175
198904	89547	293216	147416	327555
199726	94766	303688	152052	320461
200000	100000	314160	157080	314160
199726	105234	324632	162539	308487
198904	110453	335104	168476	303391
197538	115643	345576	174942	298830
195629	120791	356048	182002	294690
193185	125782	366520	189725	291393
190211	130902	376992	198197	287996
186716	135837	387464	207515	285241
182709	140647	397936	217798	282879
178201	145399	408408	229184	280889
173205	150000	418880	241840	279253
167734	154464	429352	256569	277833
161803	158779	439824	271827	277004
155429	162932	450296	289711	276371
148629	166913	460768	310012	276053
141721	170711	471240	325456	276045
133826	174354	481712	359954	276284
125864	177715	492184	391044	276952
117557	180902	502656	427585	277861
108928	183867	513128	471073	279007
100000	186603	523600	523600	280596
90798	189101	534072	599730	282427
81347	191355	544544	669406	284572
71674	193358	555016	774366	287039
61803	195106	565488	914979	289836
51764	196593	575960	1112669	292971
41582	197815	586432	1410291	296452
31287	198769	596904	1907840	300300
20906	199452	607386	2905318	304522
10467	199863	617848	5902707	309136
0	200000	628320	ad infinitum	314160

These tables may be carried to any degree of accuracy by increasing the subdivision of the arcs.

Ex. $\left.\begin{matrix}\text{The arc} = 9\\ \text{chord} = 8\end{matrix}\right\}$ to find the sagitta.

Here $\dfrac{100{,}000\times 4}{8}=112500$

And $112733-110383=1895$

Also $148629-141721=6908$

and $33087-29289=3798$

Again $\dfrac{1662\times 6908}{1895}=6059$

and $\dfrac{1662\times 3798}{1895}=3331$

Then $6059+141721=147780$

and $3331+29289=32620$

Now $\dfrac{32620+8}{147780}=1\dfrac{5659}{7381}=1\dfrac{3}{4}$ nearly

$\therefore$ the value of the sagitta required.

The minimum ratio of the arc and its sagitta may thus be determined by the differential calculus.

Let arc $=2x$

then $\dfrac{2x}{\text{sagitta of } 2}$ or $\dfrac{x}{\text{vers } x}$ will be the minimum ratio required

$$\therefore u=\frac{x}{\text{vers } x} \text{ and } \frac{du}{dx}=\frac{\text{vers } x - x\,.\,\sin x}{\text{vers}^2 x}=0$$

$$\therefore x=\frac{\text{vers } x}{\sin x} \text{ which gives } x=133^\circ\ 33'\ 48''\ 29''' = 2.3311222$$

when the rad $=1$ and sagitta $=1.6891576$.

$\therefore$ The minimum ratio of the arc and its sagitta is

$$\frac{2x}{\text{sagitta } 2x}=\frac{4.6622444}{1.6891576}=2.7601004$$

Now $2.7601004\times 100{,}000 = 276010{\cdot}04$

And it may be proved by reference to the table that this, which the differential calculus gives as a minimum, is the minimum, for it will be seen to be less than any other number in the column.

Art. XXIV.—*On the Vents of Hot Vapor in Tuscany, and their relations to Ancient Lines of Fracture and Eruption;* by Sir Roderick Impey Murchison, G.C.St.S., F.R.S., G.S., L.S.*

Introduction.—In surveying the principal localities of those remarkable vents of hot vapor in the Tuscan Maremma, called "Lagoni," "Fumacchi," "Fumarole," "Soffioni," "Mofetti," and even "Volcani,"† I perceived that their issue took place upon ancient parallel lines of fracture, along which serpentinous and other eruptive rocks had been emitted. As I am not aware that this coincidence in lines of eruption, acted upon at epochs so remote from each other, has been previously adverted to in any geological account of Tuscany, I will first call attention to the phenomenon. I shall next take this opportunity of expressing my opinion respecting the origin of the "gabbro rosso" of the Tuscans, a rock intimately associated with serpentine; and, after a brief allusion to recent earthquake shocks along the same lines, the memoir will be terminated by glancing at the simultaneous production of great divergent elevations in Italy and in the Alps, after the deposit of the nummulitic eocene formation.

Hot vapor vents.—If the intensely hot vapor gusts which have issued for centuries from cavities in the rocks of the Tuscan Maremma had been as well known to Dante, as they were to Targioni Tozzetti their graphic describer in the last century, the great poet would surely have selected them as a finer illustration of infernal agency than the feeble "bullicami" of Viterbo.‡ In our own day the chief features of the Tuscan escapes of hot gases impregnated with mineral acids have already been described by Mr. Babbage in Murray's 'Hand-book of Central Italy,' and subsequently they have been connected with a geological sketch of other parts of Tuscany by Mr. W. J. Hamilton, Sec. G.S.§ In order, however, to render my own view clear, I must offer a slight outline of the chief phenomena.

In addition to other substances, the hot vapors of Tuscany are charged with boracic acid, known elsewhere only in the active volcano of Stromboli. For the extraction of this last mentioned salt, the extensive works of M. Lardarel have been entered upon at the following nine localities, viz.: Lardarello or Monte Cerboli, Lustignano, Monte Rotondo, Sasso, Il Lago, Castel Nuovo, St.

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* From the Quart. Journ. of the Geological Society, vi, 367, November, 1850.

† For Italian descriptions of the Lagoni, see *Gio. Targioni Tozzetti*, Viaggi; *Repetti*, Dictionario fisico, &c. della Toscana, tom. iii. p. 369; *Bartolini*, Atti dei Fisio critici, tom. vi. p. 325; *Hasenqui*, Commentario (Siena), 1779: *Guerrazzi*, Contin. dei Georgofili, tom. ii. p. 455; and *Repetti*, Dizion. fisic. stor. &c. della Toscana, tom. ii. p. 624, tom. iii. p. 374, and Continov. degli Atti dei Georgofili, tom. xi, p. 49.

‡ See Lyell's Principles of Geology, 7th ed. p. 243.

§ Quarterly Journal of the Geological Society, vol. i, p. 296

Federigo, and St. Ippolito. These places are all situated in that elevated northern portion of the Tuscan Maremma which lies on the left bank of the Cecina. Thence the affluents of that river (the Pavone, Posera, Trossa, and Sterza) flow northwards; whilst the Cornia and its feeder the Melia run down to the Mediterranean in a westerly and southerly direction. The tract, penetrated at intervals by the hot gases, has a length of about eight geographical miles from N.N.W. to S.S.E., and a breadth of about five miles from W.S.W. to E.N.E.; the whole being comprised within 43° 8′ and 43° 16′ N. latitude.

Subtended generally on the E. and N. by the Cecina, this hilly tract, which is much fissured from N. 15° W. to S. 15° E., is separated on the east from the deep valley in which that river runs by a lofty ridge extending from Monte Castelli on the N.N.W. to the Gerfalco mountain on the S.S.E.; whilst another but lower ridge parallel to the above, is seen upon the western side of the gaseous district passing from Monte Rufoli to Lustignano, whence it slopes down to the sea-coast between Leghorn and Piombino. The gaseous vents occur therefore in an elevated and broken trough, on lines more or less parallel to the older flanking ridges. The general character and age of the sedimentary deposits of this region have been recently explained by myself.* It is enough then, for my present purpose, to state, that although the adjacent and undulating hills and valleys abound in marls and sands of tertiary subapennine age, and that to the south the lowest member of these accumulations is charged with coal of miocene age, the upland tract now under consideration, and from which the boracic acid fumes issue, is chiefly composed of the rocks called Alberese and Macigno. The latter containing *Nummulites*, represents, in my opinion, the eocene, and the former belongs to the cretaceous system. Professor Pilla enumerates, indeed, cretaceous fossils found in these hills, whilst the still higher ridge on the east of the tract which terminates southwards in Monte Gerfalco, as well as the ridges of Monte Calvi and Campiglia on the west, are both of jurassic age, the *Ammonites Conybeari*, Sow., and *A. costatus*, Schlth., occurring in them.

All these sedimentary rocks, from the jurassic to those of the eocene group inclusive, have been penetrated, and for the most part much altered, by igneous or plutonic rocks, the greater number of which have a serpentine character, their prevailing direction being equally N.W. by N., and S.E. by S. Upon entering this elevated tract from the north, I found that its chief town, Pomarancia,† was situated on a plateau of shelly, tufaceous, yel-

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* Quarterly Journal of the Geological Society, vol. v. p. 276, *et seq.*

† Pomarancia is the chief residence of Count Lardarel, the spirited and hospitable proprietor of the boracic acid establishments.

lowish, sandy marlstone—in parts a travertine. This band clearly overlies the subapennine marls of the adjacent hills and valleys on the north, in which the rock salt and springs of Volterra occur, and is probably of the same age as the uppermost yellow marine 'panchina' of Tuscany, or as the lacustrine deposit in the valley of the Elsa, which I have alluded to in a previous memoir.* Charged with land and freshwater shells, this rock is disposed in horizontal masses, and denuded into abrupt escarpments, which in the middle ages formed the natural defences of the old feudal town. This tertiary deposit occupies the tract between the picturesque heights of Rocca Sillana on the east, the hot springs of S. Michele on the west, and Monte Cerboli on the south, where rocks of serpentine and gabbro rise up through strata of whitish grey alberese limestone and some contiguous schists and sandstone. It is near the junction of the intrusive rocks of serpentine with the depositary strata, which are there much contorted and broken, that certain hot springs appear, four of which, at Monte Cerboli, have recently been made known and their contents analyzed by Professor Targioni Tozzetti.† His observations and analysis are of geological importance, inasmuch as they show that those springs which appear at intervals between Monte Cerboli (Mons Cerberus?) and Lardarello, where the vapors issue, define a line, as he says, from N. to S. (but accurately N. and by W., S. and by E.,) and that essentially the springs contain, though in different proportions in each, the same ingredients as the lagoni or vapors to the south of them. Thus exclusive of organic and bituminous matter, all the wells contain chlorid of sodium, carbonate of lime, the sulphates of lime, magnesia, and alumina, with boracic and silicic acids. All of them are charged with carbonic acid gas, and one of them with a minute portion of sulphuric acid gas.

The spot now called Lardarello, where the new establishment has been built, is that portion of the valley rising from Monte Cerboli and watered by the Posera from whence the hot vapors escape by orifices, which like the mineral springs, mark a a line from N. by W. to S. by E. (fig. 1.) The sides of this valley consist chiefly of alberese limestone and schists, with some points of protruding serpentinous rocks, the lower slopes being partially covered, as far as observation was possible, with

* Quart. Journ. Geol. Soc. Lond., vol. v, p. 294.

† Delle aque-termo minerali de Monte Cerboli. Firenze, 1846. Estratta della Gazzetta Toscana delle Scienze Medico-fisiche, An. 4, 2, 1. In this memoir the reader will find indications that the vapors of boracic acid had no issue in the beginning of the sixteenth century. See also notice of this tract by the early geological traveller, Targioni Tozzetti (Viaggi), whose descendant, the living Professor of Chemistry in Florence, has also published analytical descriptions of the waters of Monte Alceto, Rapolano, Monte Catini, Castrocasa, Cimiano, and Casale.

Since writing the memoir I have been informed by Dr. Daubeny that the boracic acid vapors contain nitrogen gas—thus sustaining his views on the origin of volcanic action.

1. *Lardarello and the Soffioni seen from Monte Cebero. Looking S. by E., Lardarello buildings seen three-fourths of a mile off.*

a, a. Alberese and macigno. *b.* Gabbro rosso.

younger marls. But whilst these rocks flank the fissure on the E. and W., it is quite open, as before said, to Monte Cerboli and its hot springs on the N. by W.: it also leads through undulating ground to Bagni a Morbo, about a mile distant to the S. by E., where hot mineral waters also exist. The present lagoni are artificially formed on those points where water and earth are applied to the escapes of the intensely hot vapors. Partially repressing the issue of heat, by throwing on earth and clay, and thus controlling the size of the orifices, human agency forms active mud volcanoes, the number of which and their successive operations are regulated at pleasure. From the limited space in this valley of Lardarello, so irrigated and operated upon, various columns of vapor are seen rising to different altitudes, at different degrees of intensity. This perforated ground is in a continually chaotic state from the countless changes it undergoes; and its outlines are indeed so constantly varying by the formation of fresh outlets of gas, that the traveller who should venture among its mazes without an experienced guide would be exposed to great danger. Even the workmen occasionally lose a leg, and sometimes life, when they incautiously tread upon a covering of earth too thin to prevent their sinking into a hot abyss. The orifice which I best examined was perfectly circular, about fifteen paces in diameter, and at the most active moment of ebullition. Throwing up large globules from its bubbling surface, the heated matter is ever making an effort to overflow the rim of the little crater.* Wherever the subterranean vapor escapes from a

* In his description of the Hawaiian Islands of the Pacific, Mr. Dana accounts for the absence of active eruption and projection of materials into the atmosphere, by the great dimensions of the chief crater, in which the molten matter having a very wide vent, undulates with little or no noise, and quietly overflows its lip from time to time. [To this cause, as even of more importance and partly the cause of the size and character of the vents, Mr. Dana adds, the peculiar fluidity of the lavas.—Eds. Am. J. Sci.]

crack more or less vertical, and which presents no impediment, the muddy liquid rapidly attains its maximum heat, which is so intense, that, as M. Lardarel, Jun. informed me, no instrument had yet been made to measure accurately the maximum heat beneath the surface.* It is probable that no active volcano exhibits greater heat at any point where a test can be applied. Twenty-four hours of this process suffice to saturate the bubbling mixture with boracic acid, and the stuff is then run off into flat cisterns at a lower level. The fluid is there reduced to a third of its volume by evaporation, hastened by the hot vapor being conveyed in tubes beneath the salt-pans, and thus saving the former cost of a great consumption of fuel. After the addition of soda, the desiccation proceeds, and crystals of boracic acid are formed. The violence with which the hot gas issues from any crack, provided it be vertical, is such, that if stones of some weight are thrown upon a narrow gush of it, they are heaved up several feet into the air, and heavy flagstones are required to repress the eruptive agent, and conduct a current of it down to the drying houses and pans.

It is highly interesting to compare the present issues of the hot gases and the forms of the lagoni, as arranged and controlled by man, with their natural appearance upwards of eighty years ago, when examined and described by Targioni Tozzetti. The thick white and hot sulphurous clouds rising by fits and starts,—the occasional jets of liquid rising from the boiling cauldrons,—the large and brilliant globules as they burst,—the circular shapes of the lagoni,—the incrustations of sulphur on their banks,—the crackling of the light pumiceous and hollow ground under foot,—the conversion of the contiguous alberese limestone, then considered a primary rock, into a farinaceous or mealy state,—the fumes serving as a true barometer to the neighborhood,†—the perfect salubrity of the spot to animals, though plants are there withered and blasted;—all these phenomena are nearly the same now as when our predecessor described them. But, on the other hand, some of the former phenomena are no longer recognizable. There is no more a countless number of lagoni. We cannot now, as Targioni did, look into dry cavities from which hot blasts only issued, with noises as if from a hundred bellows, and distinguish them from those holes which were then naturally filled with boiling muddy water, discharging gas; for the manufacturer now utilizes all the hot gas, and by the addition of water makes

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* Targioni Tozzetti, the old writer, does not pretend to have ascertained the extreme heat of the vapor; but Professor Pilla, on what authority I know not, places it at 140° Reaumur.

† In rainy weather, or when change is coming on, the vapors cling to the earth with increased subterranean noise, and in settled fine weather they rise to a great altitude.

gaseous orifices into mud volcanos. Nor can we any longer recognize a hot lagone approaching to the diameter of sixty *braccie*, which Targioni gives as the maximum size; still less have we a little island floating in such a hot lake. The noises and reverberations in the caverns, which he compared to the beating of a hundred fulling-mills, were doubtless much more overpowering formerly than now, when the apertures are so much closed in, and the issue so regulated. We learn, however, from the above-mentioned faithful historian two points of importance in the consideration of these forms of volcanic action:—1st. That although the lagoni were then said to be increasing in number, one of the orifices at Monte Cerboli, and another at Castel Nuovo, had ceased to act in his time. 2ndly. That flames were said to issue by night.*

That a connection exists between the Soffioni and the former geological eruptive agency of Tuscany is apparent, the moment we collate the present and the former phenomena. The inference is indeed determined by an appeal to the very line under consideration. (see fig. 2.) Beginning at the north by west, we see at S. Michele a copious outburst of serpentine and gabbro, and with it much contortion and rupture of the contiguous alberese limestone; and just at this junction, the hot springs of S. Michele, celebrated for many ages for their medicinal virtues, have their issue. Proceeding thence over undulating ground, for the most part occupied by tertiary tuff, we again find at Monte Cerboli (Mons Ceberus) on the S. by E., a like conjunction of similar eruptive rocks and dislocated strata, and with them the issue of the before-mentioned hot-springs. Thenceforward to the S. by E., the

2. *Ground plan.*

a, *a*. Alberese and macigno (cretaceous and eocene).
b, *b*. Altered alberese and macigno.
c. Gabbro rosso.
d. Thermal springs.
e. Lagoni or Soffioni.

* Targioni Tozzetti quotes Ugolino da Monte Catini's description of the fumes at Castel Nuovo, near to the baths of Bagni a Morbo, and cites his omission of any allusion to those of Monte Cerboli as an indication that the latter have burnt out since that time.

connection alluded to becomes much more interesting; for, as before said, four hot springs boil up *in the same linear direction*, and it is important to remark, that of these, the spring which is nearest to the lagoni partakes most of their boracic character. In short, the springs and the Soffioni charged with sulphuric, carbonic, and boracic acid, issue upon the very same line; and in following this line a little further to the S. by E., we reach Bagni a Morbo, where hot sulphureous springs issue from fissures in rocks similar to those of S. Michele and Monte Cerboli. Still further to the S.S.E. the boracic acid fumes reappear in a remarkably picturesque cleft of the rocks of macigno, at Castel Nuovo, where the linear direction of the vents is very striking.*

We have thus along a distance of about six or seven English miles from N. by W. to S. by E., the clearest possible evidence that the present hot springs and vapors issue upon a line of fissure, in the alberese and macigno formations, which was formed in very ancient times, *i. e.*, as I believe, between the eocene and miocene periods; the production of such fissure having been accompanied by the outburst of great bosses of serpentine and other plutonic rocks.

By extending this observation I perceived that the other "Soffioni" of this tract exist under similar conditions, showing either the actual outburst of hot springs and vapors along such line of former eruption, or the close parallelism of the two lines of phenomena. Thus, in my journey to the miocene coal tract of the Maremma before described,† I found the little town of Monte Rotondo to be built upon a junction of serpentine with the sedimentary strata it had traversed; and in looking from that spot to the N. by W., I saw the vapors of Soffioni, which bear the same name, issuing, like those of Lardarello, from a valley encased in flanking ridges of the same hard rocks. Again, the sulphureous lake, about two miles west of Monte Rotondo, having a major ellipse of north and south, is distinctly a prolongation of one of the numerous cracks extending thence to the N. by W. towards Lustignano, by which boracic acid escapes.

In mentioning these "Soffioni," Professor Pilla‡ has specially described those of Sasso, and although he has not noted the coincidence on which I lay so much stress, any one who refers to his wood-cut representing the issue at Sasso, will see that the line of vapor issuing from cavities is parallel to the main direction of the encasing ridges.§ Now, these ridges of alberese and macigno

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* This is well described by Targioni Tozzetti.

† See Quart. Journ. Geol. Soc., vol. v, p. 292.

‡ Trattato di Geologia, p. 282. Pisa, 1847.

§ I cannot but express a hope that Mr. Babbage will at some time give to the public a copy of the suggestions he furnished to the Grand Duke of Tuscany, for the extension of the useful employment of these hot gases, which might thus serve to convert a barren tract into a wealthy manufacturing district.

have either a dominant direction from N. by W. to S. by E., or are perforated along such line by the serpentine, granitone (greenstone), or other eruptive rocks, including gabbro, to which I shall afterwards advert; and hence it appears, that the ancient lines along which nature expended some of her grandest energies in this region, are also those along which she still manifests the present escape of hot springs and gases. Again, these hot gases still produce, though on a small scale, those conversions or metamorphisms of the strata on the sides of their escapes, which the geologist can well understand to have operated more largely and powerfully at that period when great masses of serpentine and other igneous rocks were evolved (or strove to be evolved) under enormous pressure, through the younger secondary and oldest tertiary deposits. At Lardarello, for example, small portions of the ordinary alberese limestone have been and are still converted into sulphate of lime by the action of sulphuric acid fumes; and the schistose calcareous shale is baked by the intense heat into brittle porcelain rock of a red color. But I would here observe, that in these recent and partial metamorphoses by natural causes, as in those of ancient date, traces of the original lamination or stratification are nearly always perceptible in the lumps or masses so affected or altered.

Gabbro Rosso.—The last observation leads me to offer some remarks on the nature and origin of the "gabbro rosso" of the Tuscans; for after an attentive examination of this rock throughout the tract immediately to the north of the boracic acid country, I feel compelled to express my dissent from the opinion of Professor Paul Savi, in which my friend Mr. W. J. Hamilton in his description of the geology of Tuscany has coincided. The chief masses of "gabbro rosso" lie in the tract south of Pisa, and east and southeast of Leghorn, which is bounded on the north by the valley of the Arno, and on the south by that of the river Cecina. The varieties of this rock are instructively exhibited in the ridges of alberese and macigno, which form the east and west sides of a longitudinal depression occupied by subapennine marls, that extend from Salveti near the Pisan valley on the N. by W., to the valley of the Cecina on the S. by E. The direct road from Pisa to the Maremma is conducted along this depression. The westernmost of these ridges, which forms the bold coast, south of Leghorn, containing much granitone, serpentine, and other varieties of eruptive rock, also exhibits, particularly along its eastern face, a good deal of the "gabbro rosso," which, as Professor Pilla informed me, obtained this name from the village of "Gabbro," a few miles southeast of Leghorn, which is built on the summit of a conical hill composed of such rocks;—I say rocks called "gabbro," because I shall presently show, that two rocks of entirely different origin have been united under this one name.

The eastern or inland ridge rises boldly up into the mountains which proceed from the north of Monte Vaso to Castellina Marittima on the south, and it is in reference to this group of hills, on the eastern part of which Monte Catini is situated, that I specially call attention, as it affords ample materials for settling the question which has arisen between Professor P. Savi and Mr. W. J. Hamilton on the one hand, and the late Professor Leopoldo Pilla and myself on the other. The two former have endeavored to show that whether in its globular and amorphous form, or in its thin-bedded state,* the rocks they call "gabbro rosso" are metamorphic; whilst Professor Pilla and myself contend that the amorphous, variolitic gabbro must have been erupted in a molten state, whether we consider its composition and unbedded condition, or the part it has played in protruding through, overturning, breaking, and altering the pre-existing strata. And although my deceased friend Pilla has to a certain extent published this opinion, he has not sufficiently illustrated his views, and I am therefore the more anxious to do him justice, and to adduce some of the reasons he assigned when we visited the tract together. The opinion of an attentive and lively observer of igneous action like Pilla, a Neapolitan by birth, who during many years was occupied in examining Vesuvius, is surely entitled to much consideration in determining such a question, even had not the physical and geological relations of the phenomenon seemed to me quite conclusive. Between Castel Anselma and Civito Castellina, I inspected natural sections, where the gabbro had not only penetrated the alberese limestone, but had thrown it off in shreds, contorted fragments, and folds on the sides of the eruption. Now, the red gabbro which had manifestly thus acted was entirely an unbedded, amorphous, felspathic mass, for the most part made up of spheroidal concretions having a variolitic structure, *i. e.* with small pustular or globular surfaces in each of the folds or concentric layers into which the large nodules exfoliate. This variolitic surface was specially pointed out to me by Pilla as a proof of the rock having been in complete fusion; inasmuch as the same forms occur frequently in ancient plutonic rocks and in the modern volcanic products of Vesuvius. The rock is, besides, often cellular and amygdaloidal as well as veined, like some of our earthy Scottish traps, occasionally containing crystals of carbonate of lime, analcime, and also the peculiar mineral caporcianite, a variety of stilbite. Chemically considered, this rock is little else than a variety of greenstone. In other words, it is one of those products, accompanying greenstone and serpentine, which has been much impregnated by iron, and which under the blowpipe melts as

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* See Mr. Hamilton's translation of Savi's description, Quart. Journ. Geol. Soc., vol. i, p. 288.

easily as wax. This is the "gabbro rosso," which I consider to be a true eruptive rock, and which rises up into an amorphous

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a. Alberese. *b*. Alberese with mineral veins. *c, c*. Gabbro rosso.
d. Miocene? with alabaster. *e, e*. Subapennine.

mountain mass at Civita Castellina, where it performs, as above mentioned, the part of an intrusive agent. It there throws off on its eastern summit the alberese limestone in a highly fractured and mineralized condition, as seen in fig. 3. From the natural section here exhibited, it is certain that this eruption of "gabbro" took place after the consolidation of the alberese and macigno formations, *i. e.* after the younger chalk and older eocene. It is also further evident that another movement of elevation occurred after the miocene period; for not only is the limestone associated with white marls to a great extent loaded with alabaster, which some persons might infer was altered limestone, but the whole of this mass has been considered to be miocene, simply because it dips away from the alberese and gabbro in such inclined strata, and is thus placed in striking contrast with the subapennine or pliocene marls of the valley which surround a boss of "gabbro rosso" in perfectly horizontal and unbroken layers. The altered alberese at Civita Castellina has here and there serpentinous soft bands, and bears a metamorphic aspect, with a slickenside surface, accompanied by cracks and numerous veins of arragonite, all of which specially abound near the junction of the alberese with the "gabbro." Copper veins, however, either traverse the alberese or run down its junction with the gabbro; and are therefore of date posterior to the eruption of the latter. It is indeed the opinion of Pilla, that the copper veins have resulted from the same igneous action which evolved the "gabbro rosso," and are contemporaneous with that rock, whilst other authors contend that they are posterior to it. In traversing on foot the wild ridges which separate Civita Castellina from Monte Catini, where the richest copper ores abound, I witnessed repetitions of the chief phenomena above alluded to, in which, besides "gabbro rosso" and feldspathic trap, (the epidosite of Pilla), there were other rocks of this class both of greenish and purple colors, which I should class as greenstone and serpentine. All these amorphous masses, however diversified in aspect and structure, seemed to me to form parts of the same eruptive matter which has penetrated the macigno and alberese in lines running N.N.W. and S.S.E.

At Monte Catini, where Mr. Hamilton seems to have most studied it, the gabbro rosso appears in a bold promontory fronting the valley of the Cecina on the south, and Volterra on the east. The chief mass is here the same amorphous spheroidal variolite as in other places. Partially, indeed, it assumes still more a serpentinous appearance; the dull red globular lumps and spheroids being often enveloped in greenish coatings. It is not my province to allude to the splendid veinstones of copper,* occasionally quartzose, which ramify along its edges or through this "gabbro;" I content myself with saying, in reference to the point at issue, that in numerous galleries and cuttings the clearest proofs are exhibited of the homogeneity of structure of the amorphous gabbro, and of the total absence of any thing in it like original aqueous deposit. In this respect it bears no resemblance to any other metamorphosed stratum which ever fell under my notice. The variolitic arrangement of the spheroids is very striking. On exfoliation, they exhibit the pustules before alluded to on the external surface only of each concentric fold, and they fall to pieces exactly like "basalte en boule." But besides this rock, —which is the "gabbro" proper, and plays the same part in relation to the sedimentary strata as the granitone and serpentine and other adjacent rocks of a similar origin,—there is a rock also called "gabbro rosso" by Savi and Hamilton, which abounds on the eastern flank of Monte Catini and other places, which is not only totally dissimilar in composition and form from that which has been described, but which I admit is clearly a metamorphosed stratum.

This is a jaspidified red and green calcareous schist, marked by numerous thin laminæ of deposit, which is evidently nothing more than the argillo-calcareous portion of the alberese or macigno formations, which happened to be contiguous to the true gabbro when the latter was erupted. For it is plain that the amorphous gabbro (as seen in a very clear natural section) has twisted back these finely laminated jaspideous strata upon themselves at a point of eruption. That in perforating, bending back, indurating, and dislocating the schists, the intrusive matter should have communicated its color, and to some extent its mineral composition, to the argillaceous and calcareous strata thus affected by it, is nothing more than must be looked for, and is indeed frequently found to be the case under similar geological conditions. This appearance of transition, from what must be granted to be true altered sedimentary layers into the amorphous spheroidal "gabbro," has led Savi and Hamilton to think that the spheroidal red gabbro is simply a still more highly fused or altered accumulation of the

* As a wayfaring geologist, I was most hospitably received at his villa by Mr. Sloane, the intelligent proprietor of the copper mines of Monte Catini. The ore is very peculiarly diffused and merits a special study.

same aqueous matrix. When, however, we recede from the immediate point of contact, we have not only very different forms in the matrices of the altered and the eruptive rocks, but an essential difference of composition and structure. Pilla has indeed cited instances just as notable of the conversion or metamorphosis of the strata by gabbro rosso, as by granitic, pyroxenic and porphyritic rocks.* One of those examples is seen in the spot called Botro del Ribuio near Serazzano, where the spheroidal "gabbro rosso" has thrown the strata of macigno into a vertical position, and has changed them into jaspers of blood-red color, highly charged with silex and oxyd of iron.†

If, indeed, the argument about transitions from the rock which has been the agent of alteration into the strata which are altered, be admitted, we must re-open elementary questions in the physics of geology which I had supposed were long ago set at rest. We may in that way be led to abandon many conclusions at which we had arrived, in refuting the doctrine respecting certain rocks of Cornwall, Norway, and other tracts which were believed by some authors to prove transitions from granites to slates, and thus to indicate a common origin of these two classes of rock! If this method of reasoning be again entertained, (as it seems to me it is by M. Savi,) then many of the inferences which geologists have drawn concerning the posterior intrusion of granite and other igneous rocks amid depositary strata will be invalidated. For, although there are numerous examples of such phenomena, which no skeptic can assail, still there are frequent cases where it is impossible to define the precise limit between the erupted molten matter and the altered rock. It is indeed in the very nature of the phenomenon that such should happen, and the time of practical geologists can be better employed than in disputing upon such points. Some persons may indeed argue that many varieties of traps and amygdaloids were to a great extent evolved from the melting of the preëxisting strata in the crust of the globe, and I am quite ready to admit that such may have been the case. But this admission by no means removes them from that class of true eruptive rocks which, in the eye of the geologist, have acted mechanically upon the strata they have penetrated; for even some of the lavas of Vesuvius may be, in great part, fused and melted materials, formerly accumulated as marine sediment, which have been transmuted by intense heat under pressure. The practical

* In his "Richezza Minerale della Toscana," Pilla unites the "gabbro rosso" with the other ophiolitic or serpentine rocks, which having acted as partial centres of elevation and eruption, rise up as conical, elongated, and rugged mounts, detached from one another (p. 39). He describes the copper of Monte Catini as lying in a true vein, which has the peculiarity of being contemporaneous with the associated gabbro both of which are posterior to the sedimentary strata (p. 40).

† Trattato di Geologia, Part I, p. 510.

point, therefore, for which I contend is, that the amorphous and spheroidal "gabbro rosso" of the Tuscans is from its composition, and still more *from the geological part it has played*, a true plutonic and eruptive rock; whilst the red jaspidified schists, which have been also termed "gabbro," are nothing more than sedimentary strata altered by the heat attending the eruption of the adjacent masses.

Lines of former and present disturbance.—As it is along the lines of eruption of the serpentines, greenstones and gabbro, *i. e.* from N. by W. to S. by E., that nature has been repeatedly laboring to evolve heat in the west of Tuscany, so also have the secondary rocks been alienated and altered in this direction. It is on the same line that the granitic rocks of Piombino have subsequently uprisen, the average direction of the whole of the coast of this part of Italy being parallel to it.*

Further, it is on this line that the various Soffioni or vapor volcanos issue, and that earthquakes still affect most the surface. Those who would wish fully to comprehend the phenomena attendant upon the earthquake which last agitated the west of Tuscany, and particularly the tracts south of Pisa, should consult the descriptions of Professors Savi and Pilla. In accompanying the latter from Pisa to Civita Castellina, and in thus passing from N.N.W. to S.S.E. along the depression in the subapennine marls, which lies between the ridges above described as penetrated by serpentine, gabbro, and other emptive rocks, I was struck with the fact that the most powerful vibratory disturbance occurred in the low hills and hillocks of incoherent materials along this very line. The shocks from north to south being most powerful in this parallel of longitude, it was natural that they should produce the most disastrous effect in that portion of the tract where edifices were placed on slightly coherent marl that rises into hillocks void of lateral support. The buildings which rested on the adjacent harder rocks of alberese, gabbro, serpentine, and greenstone, were comparatively unaffected, whilst those which stood on marl had fallen or were much shattered. It is further worthy of notice, that in the deepest denudations among the hillocks of marl, particularly near Lorenzana, where the earth opened into chasms, subterraneous waters which had been hitherto imprisoned rose suddenly to the surface; just as if artesian wells had been sunk, and that the overlying crust of a basin had been broken through. Spouting forth sand and mud, these jets of water so threw out solid contents, that when dried up they resembled so many mole-hills with radii; the centre or box of each wheel-shaped body being composed of concentrically laminated sands, marking the

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* Pareto, Pilla, and the Italian authors show that the granite of Piombino and Elba **cuts through the serpentine.**

point at which the water issued. These appearances not only served to explain the origin of the larger muddy bosses of similar form, common in the incoherent subsoils of Calabria, which have been so frequently subject to great earthquakes, but may also be viewed as another link which connects the present small disturbances of the surface, with the former powerful subterranean energy proceeding from igneous and gaseous development we have been considering.

Thus, in reference to my preceding memoirs and in reasoning by analogy, we are led to infer, that the great evolution of molten matter in former or plutonic times, accompanied by so much heat and its gaseous attendants as to metamorphose whole mountain chains, was succeeded, as the bottoms of the sea rose, by a considerable diffusion of volcanic materials, chiefly of subaqueous origin, but in part subaërial; and that, finally, the lands assuming their present relations to the sea, the extension of molten matter has been confined to a very limited number of fissures or vents of eruption, many of which have become extinct with the lapse of time. A portion, however, of these eruptions in Europe is still in continuous activity, whether in emitting solid matter, as at Stromboli, or hot springs and vapors, as in the Tuscan Soffioni; whilst another portion is intermittent, as viewed in the paroxysmal outpourings of Etna and Vesuvius, the occasional formation of small new cones and craters under the waters of the Mediterranean and the fitful lines of earthquake shocks with their accompanying outbursts of water.

In viewing the intimate connection between all these phenomena, and in looking to the powers of the Soffioni of Tuscany, we might perhaps infer, that if these gusts of heat were entirely repressed by closing up the orifices through which they now escape, earthquakes to some slight extent might be expected still more to prevail in the neighborhood, until the expansive forces were liberated; just as the most calamitous shocks in Sicily and Calabria have occurred when Etna has been most dormant. Putting aside this speculation, the hot vapors may unquestionably be viewed as the remains of former igneous action, which I believe to have been incalculably more powerful, not only because it is on the same band or its subordinate parallels that the copious masses of plutonic rocks of this tract and the adjacent mineralized strata occur, but because this line is absolutely coincident with the axis of the Carrara and other marbles and their associated slates and crystalline rocks of the Apuan Alps. Now, as those lofty masses or western Appennines, together with their lower parallels in the Gulf of La Spezia, have been shown to be simply altered strata of jurassic age*; so in extending our observation in the same line

* See Quart. Journ. Geol. Soc., vol. v, p. 266 *et seq.*

further to the N. and by W., we find that serpentinous rocks have there, as in the Tuscan Maremma, burst through alberese and macigno and in much greater volume. In truth, the copious serpentines and their accompaniments in and around the territory of Genoa, have converted the cretaceous strata into rocks having all the appearance of palæozoic slates and flagstones. Other and posterior movements have there also affected, though for the most part mechanically, the contiguous conglomerates and sandstones of miocene age, which on the sides of the pass leading from Genoa to Alexandria occupy very highly inclined positions. The phenomena in the Genovesato and Piedmont, like those in the Tuscan Maremma*, indicate that such beds of the middle tertiary age, whether marine or freshwater, have been dislocated along those lines of disturbance, which at an antecedent period had been marked by the protrusion of the serpentinous rocks in a molten state. In other words, it was by the post-eocene eruption that the great metamorphosis of the pre-existing strata was caused. A long period of comparative repose followed, one of the earliest operations of which was the accumulation of miocene conglomerates, for the most part made up of strata previously altered by the serpentine eruptions; as seen in the hills north of Genoa and Savona on the one hand, or in the Monferrato (Superga) on the other. Another powerful disturbance subsequently took place, when these miocene beds were thrown upon their edges, or were fractured and highly inclined along the same general lines of fissures, which had been marked by a more intensely igneous activity in the previous or serpentine period.

Although the phenomena chiefly treated of in this memoir have reference to a great band of disturbance proceeding on the whole from N. N. W. to S. S. E. along a length of about 100 miles and a breadth of about 25 miles, a glance at the geological map of Italy by Collegno, combined with my knowledge of the country, has led me to think, that whilst this line of eruption contains within itself minor parallels, there are other and divergent lines, along which similar strata have been affected by the same eruptive rocks. The country of north-western Italy, which comprehends the Genovesato and the north of Parma, seems to have been the grand centre of serpentine eruption, from whence such lines radiate as marked by the protrusion at intervals of igneous rocks and the bands of metamorphosed strata which constitute the loftiest ridges of Italy, (see fig. 4, p. 215.) In this way, the serpentine bosses of the Appennines, between Bologna and Florence, that trend from N. W. to S. E.—*i. e.* from the region of chief eruption—though divergent from the line of the Apuan Alps, and Tuscan Maremma, are exactly coincident with the

* See former Memoir and Section Quart. Journ. Geol. Soc., vol. v, p. 283 to 292.

major axis of the Appennines or great back-bone of Italy, the culminating points of which, as at the Gran Sasso d'Italia, 9530 feet above the sea, are composed of eocene (nummulitic) and cretaceous rocks reposing on jurassic.

Again, if we turn from the east and look to the other great band of eruption to the west of the coast of Italy, as marked by serpentines protruding through the cretaceous and eocene deposits of Corsica, we see (as graphically laid down by Pareto*) that it marks nearly a meridian line. Looking then at Italy on the great scale, the geologist may, I think, satisfactorily connect its dominant physical features with former causes of upheaval. He sees that, as it is in the highly convulsed and broken-up region where the Appennines bend round to become confluent with the Alps, the greatest masses of serpentine have been emitted, so, exploring southwards from this grand focus, he observes that *bands of the same molten matter have been intruded into divergent cracks and fissures* in the crust of the earth, and extend in long linear directions to the S.E., S.S.E., and S. Geological investigation establishes, indeed, not only this fact, but also the important point, that such igneous matter was simultaneously emitted; since it has alone broken through and metamorphosed sedimentary strata of the same age through several degrees of latitude. Now, as few parts of Italy contain strata of higher antiquity than liasso-jurassic, and as there is no evidence that its submarine accumulations had ever been raised into dry land before the cretaceous and nummulitic rocks were accumulated upon them, we have a fair right to infer, that the linear eruptions of serpentine and their accompaniments of gas and heat, absolutely furnished the Peninsula with those chains of hard and altered strata (each containing subordinate parallels) whose features and contents have been described on a previous occasion. In short, there is no reason to believe that Italy had any well-defined terrestrial existence until the period of the post-eocene serpentinous eruptions. As Corsica, however, is only the northern prolongation of Sardinia which contains Silurian fossils, and as both islands are characterized by a meridian chain of ancient crystalline rock, it is clear that a very ancient mass of land ranged in that direction, as further proved by its old crystalline Silurian rocks being overlaid by palæozoic coal plants and a coal formation.† It is certain, therefore, that the serpentinous eruption

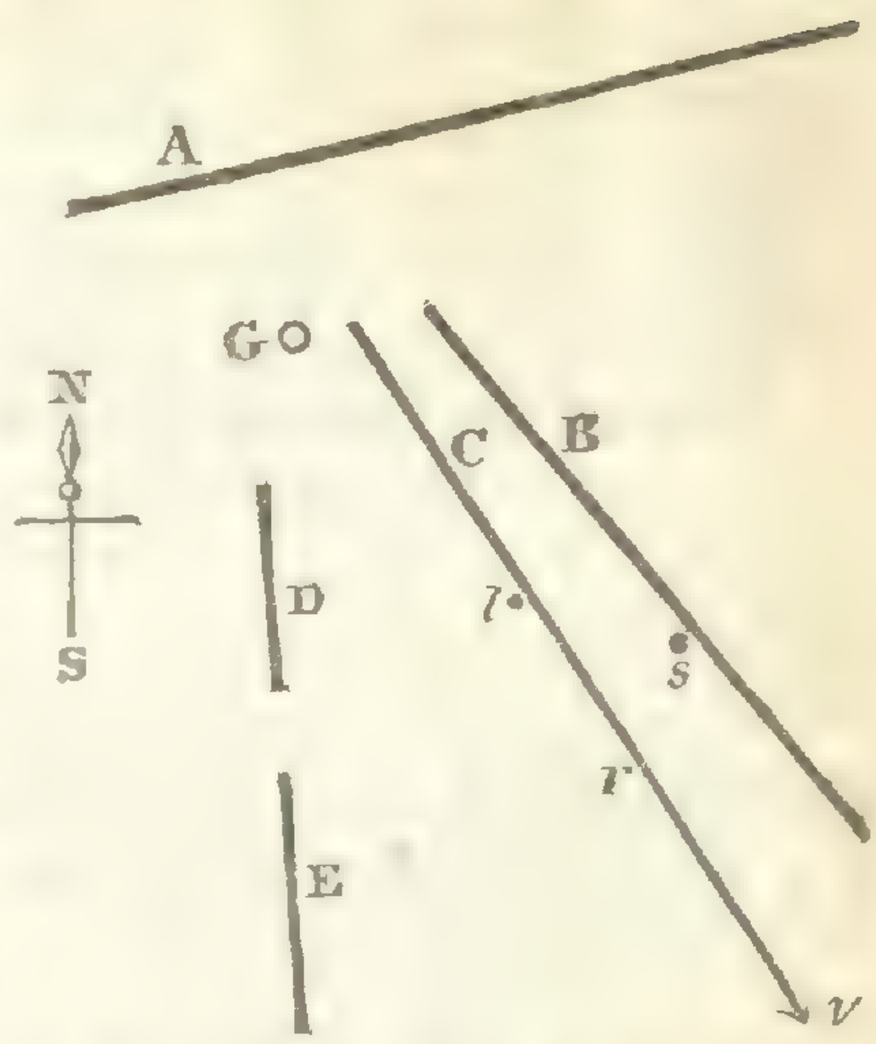
* The reader who wishes to become acquainted with the various lithological characters of the rocks classed under the head of Serpentine, and which were all emitted at the post-nummulite period, must consult the works of Pareto on Liguria Marittima, and on Corsica, both illustrated by excellent geological maps. Although the Marquis Pareto, following preceding authorities, has classed the nummulite limestone with the chalk, I trust he will now agree with me.

† After this memoir was read, Professor Meneghini of Pisa, communicated to me, that Professor Savi and himself had discovered undoubted species of coal plants

there found its issue along a line of fracture coincident with the north and south direction which had been impressed upon these lands at a very remote period—such eruption, though divergent from them, being simultaneous with the chief axes of upheaval in Italy.

In speaking of divergent lines of fracture and elevation, which offer proofs of simultaneous eruption and dislocation, I am led to terminate my communications on the Alps and Appennines, by calling attention to the great phenomena which are common to these two chains and at the same time distinguish them. To render my idea clear I have annexed the accompanying diagram, fig. 4. Whilst the direc-

4.



A. Alps—major axis.—B. Appennines.—C. Apuan Alps.—D. Corsica.—E. Sardinia.—G. Country of Genoa, serpentine rock.—*l*. Lagoons of Tuscany.—*r*. Roman Volcanoes.—*s*. Gran Sasso—*v*. Vesuvius.

(*Pecopteris arborescens* and *Annularia longifolia*) in anthracite schists, which on the right bank of the Era near Volterra form the lower part of the "Verrucano," or oldest conglomerate of Italy. A communication to this effect, on the part of his colleagues, was at the same time made by Professor Parlatore at the late meeting of the British Association at Edinburgh. This important discovery seems to prove that a lower portion of the rocks called Verrucano, which have hitherto been considered to be the natural base of the lias, is of the same palæozoic age as the conglomerates of the Valorsine and other places in the Alps. Yet still, in reference to my opinion above expressed, the plants found in Tuscany may either have been derived from lands now submerged, or from the adjacent shores, of which the Silurian and ancient crystalline rocks of Sardinia and Corsica are the existing remnants. At all events, no rocks have yet been made known to geologists in Northern or Central Italy which are of sufficient antiquity to have been the *dry land* whereon the coal plants grew, to which Professors Meneghini and Savi have drawn attention.

As Italy is thus connected still more closely with the Alps by the feature of anthracite coal plants common to both countries, I would here allude to an able recent memoir of Professor Heer (Mittheilungen der Natur. Gesellsch. in Zurich, 1850,) in which, specially referring to the case of Petit Cœur in Savoy, he argues, that the plants found there being terrestrial and of the carboniferous era, the strata in which they are imbedded cannot be united with that which contains marine liassic belemnites. The general analogical reasoning of this author is so much in unison with my wishes, as expressed in the Memoirs on the Alps, Appennines and Carpathians (Journ. Geol. Soc., Lond., vol. v, pp. 176, 177), that I have only to regret he should have omitted to acquaint his readers, that I drew my inferences solely from the *actual section and the order and position of the beds.* I clearly stated that I did so in opposition to my desire to find the plants and belemnites lying in what might be considered separate formations. With the utmost deference to the value of organic remains, I felt however bound to affirm, that in the example of Petit Cœur, the *physical evidences* seemed fairly to sustain the views of M. Elie de Beaumont and M. Sismonda. At the same time, I did not deny the possibility (though as yet unexplained by an actual appeal to facts) of accounting for this singular collocation by an extremely sharp, inverted curvature, followed of course by powerful denudation. Lastly, I would now observe, that the naturalists who are most opposed to the views of MM. De Beaumont and Sismonda have not visited the localities which they really must do before they can explain away by fair demonstration what they consider to be an anomaly.

tion of the chief ridges of Italy is more or less at right angles to the main direction of the Alps, we know that the greatest amount of metamorphism has been impressed on both chains after the nummulitic period; and again, that in both, very violent movements took place after the deposition of the miocene tertiary. In the chief range of the Swiss and Austrian Alps, the greatest changes of metamorphism, elevation, depression, and contortion have been determined upon lines having on the whole an east-northeast and west-southwest direction; whilst in the Appennines the same changes have occurred at the same periods on linear bands trending generally from N.W. to S.E., and even veering round to a meridian strike as they approach the direction of the ancient and palæozoic rocks of Corsica and Sardinia. Notwithstanding, however, their great diversity of direction, the Alpine and the Sardinian lines of active disturbance have each been manifested along primæval coasts, the strata formed upon which contain palæozoic fossils. When, however, we pass from the consideration of events so long past to the contemplation of those agents of terrestrial change which have been most active in comparatively recent times, the Appennines are at once distinguished from the Alps in possessing those truly volcanic phenomena which connect geology and existing history. With the most frequent evidences of recent mutations to an enormous extent in their outlines —*i. e.* since the period of the glacial waters*—the Alps present nowhere the trace of any subaërial volcano; the youngest igneous rocks being those which have traversed the older tertiary deposits of the Vicentin and other tracts. The Appennines, on the contrary, offer proofs, particularly on their western shores, not only of recent oscillations, but also of copious volcanic eruptions. Thus, as was recently shown, subaqueous volcanos were intensely active during the penultimate period, along a band parallel to and flanking the Appennines, which had been raised at a former epoch. After these fires were spent and their dejections raised up into the western lands of the Papal and Neapolitan states, we have no proofs of subaërial volcanicity until Vesuvius burst forth, save the case of the volcano of Latium†, whose period of activity is lost in the maze of time, and the notable examples among the early Greek settlements in the Bay of Naples.

Lastly, let us recollect, that in the tract of Western Tuscany, which has been the special subject of this memoir, we also read a most instructive lesson upon the efforts of *subterranean igneous forces to develop themselves at successive periods along one and the same established band of active change in the crust of the*

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* See "Distribution of the Superficial Detritus of the Alps, compared with that of Northern Europe." (Quart. Jour. Geol. Soc., vol. vi, p. 65.)

† Quart. Jour. Geol. Soc., vol. vi, p. 294.

globe. For whilst one extremity of this band is marked by the eruptions of Ischia and Vesuvius, where volcanic action has prevailed in the historical period, we have only to follow such zone from Naples to the N.N.W. to see that it passes along a portion of the Papal States replete with earlier volcanos, and is directly coincident with tracts powerfully affected in much more remote periods, along one of which volcanic action is still partially developed in the hot vapor issues of the Tuscan Maremma.

ART. XXV.—*On Kirkwood's Law of the rotation of the Primary Planets;* by ELIAS LOOMIS, Professor of Mathematics and Natural Philosophy in the University of the City of New York.

Messrs. Editors,—In the last number of the American Journal of Science, in noticing a small volume of mine lately published, under the title of "The recent progress of Astronomy, especially in the United States," you say, "One omission should be noticed. We do not find in this volume any allusion to Kirkwood's celebrated law connecting the rotations of the planets with their masses and distances from the sun. In a history of American Astronomy especially, this discovery is entitled to an honorable mention."

As the enquiry has been made from a great variety of sources, why I have omitted in my book to make any mention of Kirkwood's discovery, I seem called upon to assign a reason for this neglect.

I might perhaps shelter myself under the protection of my Preface, in which I say, "This little volume is designed to exhibit in a popular form the most important astronomical discoveries of the past ten years. *It does not profess even to enumerate all the discoveries of this period.* Such an enumeration would have swelled the volume much beyond its present size. *Those topics have been selected in which it was supposed the public generally would feel the deepest interest.*"

The plan of my work, as here stated, must be my apology for omitting to mention even the names of many professors of astronomy in our country whose reputation is not confined to the limits of the United States; but the importance of Kirkwood's law (if it be really a law of nature) is such that even this plea would not have justified its entire omission in a work devoted to the recent progress of astronomy, *especially in the United States.* I am therefore forced to confess that my reason for omitting to notice Kirkwood's law was that I was not satisfied of its truth. Having made this public confession, I am bound to give my reasons for withholding my assent to the law.

The following is the law in question, as stated by its author in this Journal, vol. ix, page 395 :—

"Let P be the point of equal attraction between any planet and the one next interior, the two being in conjunction : P′, that between the same and the one next exterior.

"Let also D = the sum of the distances of the points P, P′, from the orbit of the planet; which I shall call the diameter of the sphere of the planet's attraction ;

"D′ = the diameter of any other planet's sphere of attraction found in like manner ;

"n = the number of sidereal rotations performed by the former during one sidereal revolution round the sun ;

"n' = the number performed by the latter ; then *it will be found* that $n^2 : n'^2 :: D^3 : D'^3$; or $n = n'\left(\frac{D}{D'}\right)^{\frac{3}{2}}$."

That is, *the square of the number of rotations made by a planet during one revolution round the sun, is proportional to the cube of the diameter of its sphere of attraction ;* or $\frac{n}{D^{\frac{3}{2}}}$ *is a constant quantity for all the planets of the solar system.*

The simple question for us now to consider is whether this proposition is *true.* To test it, however, is a matter of more difficulty than might be anticipated. It involves the knowledge of the distances, masses, and the times of revolution and of rotation of all the planets of the solar system. Now there is some uncertainty with regard to the mass of each of the planets ; and still greater uncertainty with regard to the times of rotation of some of them upon their axes. Moreover, between Mars and Jupiter, we find a group of planets ; and the assumed law applies to them at a time when they are supposed to have been all united in one body. Of course there is an uncertainty with regard to all the elements of this planet, and we are left to conjecture the time of its rotation upon its axis. It is then difficult to bring this assumed law to the test of truth. Under these circumstances it has appeared to me the most satisfactory course, to take those elements of the planetary system which have the strongest independent probability, and compare them with this law ; and when we find discrepancies, to enquire whether it is admissible to vary the assumed elements so as reduce them to an entire harmony with the proposed law. This I have accordingly attempted, and the result is shown in the following table, where column first exhibits the planets in the order of their distances from the sun ; column second exhibits their mean distances, that of the earth being taken as unity ; column third exhibits their masses, the sun being taken as unity ; column fourth exhibits the diameter of the sphere of attraction of each of the planets computed after the manner of

Kirkwood; column fifth exhibits the sidereal times of revolution of each of the planets round the sun; column sixth, the probable times of rotation upon their axes; and column seventh exhibits the computed value of $\frac{n}{D^{\frac{3}{2}}}$, which, according to Kirkwood, should be a constant quantity. Columns second and fifth are taken from the last edition of Sir J. Herschel's Astronomy, with the exception of Neptune, which is taken from Mr. Walker's computations, and the asteroids, which are taken from the latest orbits; column third is taken from Encke's Memoir in the Ast. Nach., No. 443, with the exception of Neptune, which is derived from Bond's observations of the satellite; and the asteroids, which I have assumed as together equal to Mars; column sixth is taken from Mädler's Populäre Astronomie, 4te Auflage, with the exception of the Asteroids, whose period is assumed at 27 hours, being the time assigned for Juno in the Edinburgh Encyclopædia, vol. ii, page 601, and Uranus, which is taken from Herschel's Astronomy, page 648.

	Mean distance.	Mass.	Diameter of the sphere of attraction.	Sidereal revolution.	Rotation on axis	C.
				d.	*h.* *m.* *s.*	
Merc'y,	0·3870981	$\frac{1}{4865751}$		87·9692580	24 5 28·3	
Venus,	0·7233316	$\frac{1}{401839}$	0·395664	224·7007869	23 21 21·93	928
Earth;	1·0000000	$\frac{1}{359551}$	0·525483	365·2563612	23 56 4·09	961
Mars,	1·5236923	$\frac{1}{2680337}$	0·651042	686·9796458	24 37 20·4	1275
Astr'ds,	2·545	$\frac{1}{2680337}$	0·562186	1488	27 0	3138
Jupiter,	5·2027760	$\frac{1}{1047·371}$	5·409019	4332·5848212	9 55 26·56	833
Saturn,	9·5387861	$\frac{1}{3501·6}$	8·546946	10759·2198174	10 29 16·8	985
Uranus,	19·18239	$\frac{1}{24905}$	7·719884	30686·8208296	9 30	3614
Nept'ne	30·0395	$\frac{1}{19405}$				

The numbers in the last column of this table are not constant, as Kirkwood's law requires, but exhibit on the other hand great discordances. Let us then, in accordance with our proposed plan, proceed to inquire whether it is admissible to vary the elements employed so as to harmonize all these numbers.

I. The greatest discrepancy is in the case of Uranus. Is it allowable to vary the elements employed in this computation, so as to reduce the value of C found for Uranus to agree with that found for either Venus, the Earth, Jupiter, or Saturn? The mean distances of Saturn, Uranus, and Neptune, cannot be materially changed; their masses are liable to some uncertainty, but not enough to vary the diameter of the sphere of attraction of Uranus by one-twentieth of its whole value. The time of revolution of Uranus about the sun is well known. The only remaining element which enters into the computation, is the rotation of Uranus upon its axis. If we assume that this planet requires thirty-seven

hours to make a rotation upon its axis, the value of C computed for Uranus will agree with the mean result derived from Venus, the Earth, Jupiter and Saturn. Mr. Walker, by employing somewhat different data, (Am. Journal, vol. x, p. 22,) has obtained a result of thirty-three and a half hours. The question therefore presented for our decision is, can we admit that Uranus requires from 33 to 37 hours to make one rotation upon its axis? I think this assumption inadmissible for the following reasons:

1. Laplace in the Mec. Cel., vol. iv, p. 356, says, "the time of rotation of Uranus is not probably much less than that of Jupiter or Saturn;" and in the last edition of Herschel's Astronomy, page 648, the time of rotation is given at $9^h\ 30^m$?

2. A similar conclusion follows from the observed figure of the planet. Sir William Herschel remarked that the disc of Uranus was sensibly flattened; and Prof. Mädler has carefully measured the diameters of this planet, which indicate a compression of $\frac{1}{9.6}$, or almost exactly *one tenth*, which is fully equal to that of Saturn, and greater than that of Jupiter.

If it be admitted that the figure of Uranus is the figure of equilibrium of a planet once fluid, (and this will not probably be disputed by the believers in the nebular hypothesis, to which Kirkwood's law is thought to have added new probability,) then we can compute the velocity of rotation of the planet upon certain hypotheses with regard to its density. According to Laplace, (Mec. Cel., vol. ii, p. 310), the limits of the oblateness of a planet are $\frac{1}{2}\alpha\ q$ and $\frac{5}{4}\alpha\ q$; where $\alpha\ q$ represents the ratio of the centrifugal force to the force of gravity at the equator. The first limit corresponds to the case where all the matter of the planet is collected in the center; and the second corresponds to the case where the mass is homogeneous. If we suppose Uranus to make a rotation in seven and a half hours, the oblateness upon the first hypothesis is one tenth; and if we suppose the planet to make a rotation in twelve hours, the oblateness on the last hypothesis is one tenth; while on the first hypothesis it is one twenty-fifth; and for a less velocity of rotation, the oblateness in either case would be still less. Therefore, we cannot suppose Uranus to require more than twelve hours to perform a rotation upon its axis, and it probably does not require over ten hours.

3. The analogy of Uranus with the other planets leads to a similar conclusion. I shall refer to this analogy hereafter on page 222.

I do not therefore perceive how Uranus can be reconciled with Kirkwood's law, by any admissible assumption with regard to the value of its elements.

II. We find a similar discrepancy in the value of C computed for the Asteroids. Are we permitted in this case to assume elements which shall harmonize with Kirkwood's law? The re-

flection naturally suggests itself, that inasmuch as several new asteroids have recently been discovered, we must be quite ignorant of their total number; and hence if these planets were once united in a single body, there must be great uncertainty with regard to its mass and the dimensions of its orbit. It is, however, remarkable that the average distance of the thirteen asteroids now known, differs from the average of the four which were first discovered, by little more than *one thirtieth* of its whole value; which affords a presumption that we have discovered nearly the center of gravity of the system. With regard to the total number of the asteroids, we are entirely ignorant; but we may safely infer that those which remain to be discovered are quite small. According to Mädler, the volume of Vesta is $\frac{1}{2}\frac{1}{4}\frac{1}{1}\frac{1}{2}$ that of Mars, and that of Pallas is $\frac{1}{2}\frac{1}{2}\frac{1}{5}$ of Mars; in other words, the planet Mars would furnish 225 asteroids as large as Pallas. Now Pallas is certainly above the average size of the asteroids; from which we infer that the volume of all the known asteroids amounts to only about *one twentieth* of Mars. It seems then to be a very liberal allowance to admit that all the asteroids, discovered and undiscovered, are equal in volume to the planet Mars. Mr. Walker has computed (Am. Jour., vol. x, p. 22) that a planet with a mass *double* that of Mars would harmonize perfectly with Kirkwood's law. The existence of so large a mass appears to me improbable.

In order to make the value of C computed for the asteroids harmonize with the mean result derived from Venus, the Earth, Jupiter, and Saturn, we must suppose the original planet to have revolved upon its axis once in 91 hours. Mr. Walker by assuming a mean distance of 2·9 (which I think inadmissible) and a double mass, has obtained a period of 58 hours. Is this an allowable supposition? I infer not, for the following reasons:

1. Schröter inferred from his observations that the planet Juno revolved upon its axis once in 27 hours.

2. From the analogy of the other planets which I shall consider on the next page.

III. The value of C computed for the planet Mars does not harmonize well with Kirkwood's law.

Mr. Walker has computed (Am. Jour., vol. x, p. 22) that if we assume the mass of Mars to be $\frac{1}{2}\frac{1}{1}\frac{1}{6}\frac{1}{7}\frac{1}{4}\frac{1}{6}\frac{1}{4}$, and employ his elements of the asteroids, Kirkwood's law will be satisfied. So large a mass for Mars appears to me inadmissible. Delambre long ago computed the mass of Mars to be $\frac{1}{2}\frac{1}{5}\frac{1}{4}\frac{1}{6}\frac{1}{3}\frac{1}{2}\frac{1}{6}$, (Mec. Cel., vol. iii, p. 334). Burckhardt in the Connaissance des Tems for 1816, diminished this by one twentieth, making it equal to $\frac{1}{2}\frac{1}{6}\frac{1}{8}\frac{1}{6}\frac{1}{3}\frac{1}{3}\frac{1}{7}$, and this is the mass now generally adopted. To increase it without any authority by more than *one fifth* of its value, seems altogether inadmissible.

IV. The values of C computed for Jupiter and Saturn do not harmonize as well as ought to be expected if Kirkwood's law is indeed a law of nature; but upon this I will not insist, as the computed sphere of attraction of Jupiter depends upon the mass and distance of the next interior planet, with regard to which there is considerable uncertainty.

I will now proceed to examine some of the analogies already alluded to, as existing between the planets of our system. We shall find that the planets are naturally divided into two classes, each distinguished by peculiar characteristics. This will appear from the following table, in which, column second exhibits the true diameter of each of the planets, and column third their density, (the earth being taken as unity:) column fourth shows the time of rotation upon their axes, and column fifth the compression of each planet as far as it has been determined.

	True diameter.	Density.	Rotation.	Compression.
Mercury, ...	0·398	1·225	$24^h \cdot 1$	
Venus, ...	0·975	0·908	23 ·3	
Earth, ...	1·000	1·000	24 ·0	$\frac{1}{299}$
Mars, ...	0·517	0·972	24 ·6	$\frac{1}{38}$
Asteroids, ...				
Jupiter, ...	10·860	0·227	9 ·9	$\frac{1}{13 \cdot 7}$
Saturn, ...	9·982	0·131	10 ·5	$\frac{1}{10}$
Uranus, ...	4·332	0·167		$\frac{1}{10}$
Neptune, ...	4·741	0·230		

It is obvious at a glance that the first four planets in this table exhibit a strong family likeness, and the last four constitute a second family. Thus the diameters of the first class range between four and ten; the diameters of the second class range from forty-three to one hundred and eight. The average diameter of the second class is *ten times* that of the first class; while in each class, the smallest planet is four tenths of the greatest. Also the densities of the first class range from 0·9 to 1·2; those of the second class range from 0·13 to 0·23. The average density of the first class is *five times* that of the second; while the individuals of each class do not differ greatly among themselves.

The average time of rotation of the first class is *two and a half* times that of the second class; while the velocity of rotation for the several individuals of each class is almost identical.

The compression of the planets of the first class is small and difficult to measure. If the compression of Venus was the same as that of the earth, it would make but one-thirtieth of a second difference between its polar and equatorial diameters when in superior conjunction, a quantity too small to be sensible in micrometric measurements. The compression of Mars has been vari-

ously estimated. Sir William Herschel states that the polar diameter is about $\frac{1}{16}$ less than the equatorial diameter; but according to Arago, the two diameters are in the ratio of 189 to 194 which gives a compression of $\frac{1}{35}$. Even this compression appears irreconcilable with the supposition that the figure of the planet is the figure of equilibrium of a fluid body.

The compression of the planets of the second class varies from $\frac{1}{14}$ to $\frac{1}{10}$.

The compression of a planet depends not merely upon its velocity of rotation, but upon the ratio of its centrifugal force to the gravity of the planet, and upon the law of density from the surface to its center. The centrifugal force can be computed when we know the time of rotation, but the law of density in the interior of the planet we have no direct means of determining.

Here then we find two classes of bodies with characteristics plainly marked; and if we suppose the asteroids to have been once united in a single body, probably no one would hesitate to assign it to the first of these classes.

These coincidences are so striking that we seem irresistibly led to the conclusion that the time of rotation of Uranus upon its axis cannot much exceed that of Jupiter or Saturn; and it is improbable that the period of the asteroid planet could much exceed twenty-four hours.

I cannot therefore agree with Mr. Walker in his conclusion that "whether Kirkwood's analogy is or is not the expression of a physical law, it is at least that of a physical *fact* in the mechanism of the universe." Even if future discoveries should prove it to be a *fact*, the law seems irreconcilable with what we must at present regard as the most probable values of the planetary elements. It is however much to be desired that the periods of rotation of each of the planets, particularly that of Uranus, should be determined with all possible precision, in order that any uncertainty which now rests upon this subject may be entirely dissipated.

Art. XXVI.—*On a new Genus of Crustacea in the Collections of the U. S. Exploring Expedition under Capt. C. Wilkes, U. S. N.*; by James D. Dana.

The genus Trapezia, as instituted by Latreille and accepted by authors, embraces two distinct genera, which are similar in the general form and appearance of the species, but are readily distinguished by several characters. The *Trapezia cymodoce* is the type of the true Trapeziæ, the *T. digitalis* or *glaberrima*

of the other genus. The following are their characteristics, omitting the points in which they agree.

Genus Trapezia.

Frons sinuosus vel 6–8-dentatus.

Maxillipedes externi marginem posticum fere transversi; apices que articulorum secundorum inter sese valde remoti.

Superficies prælabialis viaque efferens lineâ elevatâ divisæ margoque buccalis anticus utrinque emarginatus, emarginatione viæ efferentis ostio.

Pedes antici elongati, brachio extra carapacem valde exserto, margine brachii antico denticulato et apicem anticum acuto, manu fere rectâ, pollice parce deflexo.

Pedes 8 *postici* non unguiculati, tarso apicem pusillè producto et truncato.

Abdomen maris sæpius 5-articulatum.

Genus Tetralia.

Frons rectus aut rectiusculus, subtilissimè denticulatus.

Maxillipedes externi marginem posticum valde obliqui, apices articulorum secundorum inter sese paulo remoti.

Superficies prælabialis viaque efferens lineâ paulo elevatâ divisæ sed margo buccalis anticus vix emarginatus.

Pedes antici breviores, brachio apicem paulo exserto, margine brachii antico apicem rotundato subtiliterque denticulato, pollice valde deflexo.

Pedes 8 *postici*, breviter unguiculati.

Abdomen maris 7-articulatum.

The name *Tetralia*, from the Greek τετρα *four*, alludes to the subquadrate form of the species. The *Grapsilla* of M'Leay, as shown by Krauss and others is identical with Trapezia. The want of a proper claw to the tarsus in the Trapeziæ is a striking character, and is an anomaly among the Cancrinea. The extremity appears truncate in a side view as well as in an upper, and has nothing of the texture of a claw except in its minute points or setæ; while in Tetralia the tarsus is pointed in a side view though somewhat truncate as seen vertically; and the texture of the extremity is horny like a regular claw, which same texture extends back on either side.

In the closed orbits, the antennæ being wholly excluded, and in the ridge separating the efferent canal from the prælabial space as well as the narrow form, these genera are related to Eriphia. Fuller descriptions with many illustrations will be given in the Author's Report on the Crustacea of the Expedition, now ready for the press.

Art. XXVII.—*Mineralogical Notices.* No. II.*

On the Hardness of Minerals; by R. Franz, (Pogg. Ann., lxxx, 37.)—This very important memoir relates to the comparative hardness of crystals on different surfaces, and in different directions on the same surface, and contains the results of numerous careful observations.

Dopplerite, a new species.—This mineral, of vegetable origin, occurs in Styria near Aussee, in peat. According to Doppler, (Wien Acad. Ber., Nov. Dec., 1849, 239,) and Haidinger, (ibid, 287,) it is when fresh, brownish black with a dull brown streak and greasy subvitreous lustre, and also in thin plates which are reddish brown by transmitted light. G = 1·089, according to Fötterle. On exposure to the light, the substance becomes very elastic like caoutchouc. Heated to 100° C., when it loses 78·5 p. c. of water, it resembles a black pitch; on heating the fresh mineral with potash, ammonia is given off. Analysis afforded Schrötter, (Wien Acad. Ber., 1849, 285,)

C 51·63 H 5·34 O 43·03

giving the empirical formula $C^8H^5O^5$. Schrötter considers it an unusually pure and homogeneous peaty substance from whose cellulose 2 parts of water are removed—$C^8H^7O^7$ losing 2HO becomes $C^8H^5O^5$, the formula above.

Magnesite.—Breithaupt (Pogg., lxxx, 313,) found the angle of a magnesite from Snarum, Norway, 107° 28½′. Scheerer obtained for the mineral on analysis—

	Ċ	Ṁg	Ḟe	Ḣ
1.	51·447	47·296	0·786	0·470
2.	52·768	47·232	*undetermined*	

The formula from the first analysis is Ṁg Ċ.

Nemalite of Hoboken, New Jersey.—Analysis by Rammelsberg, (Pogg. Ann., lxxx, 284,)

	Ṁg	Ḟe	Ḣ	S̈i
	64·86	4·05	29·48	0·27=98·65
Oxygen,	25·49	0·90	26·20	

This result, giving for the formula of Brucite, Ṁg Ḣ, confirms the recent analyses of Whitney, (J. Bost. Nat. Hist., 1849, p. 36,) and Wurtz, (Dana's Min., 3d. edit., p. 682.)

Chlorite.—Delesse obtained (Ann. d. Mines, [4], xvi, 520) for a dull bluish green chlorite of feathery texture, from the Mandelstein porphyry of Oberstein, and of Planitz near Zwickau, the following composition:—

	S̈i	Ä̇l	F̈e	Ḟe	Ċa	Ṁg	Ḣ
1. Oberstein,	29·08	42·00		——	3·70	12·23	12.99=100·00
2. Planitz,	29·45	18·25	8·17	15·12	0·45	15·32	12·57= 99·33

* For Notices, No. I, see preceding volume, p. 245.

In the first of these analyses the magnesia was estimated from the loss.

[The second analysis gives for the oxygen ratio of the protoxyds, peroxyds, silica and water, 9·51 : 10·98 : 15·30 : 11·17 = 8 : 9 : 12 : 9.]

Byssolite.—Kengott (Min. Unters., i, 77,) has measured the capillary crystals of byssolite from the Tyrol, and obtained the prismatic angle 124° 21′, which is that of Hornblende.

Ægirine.—The Ægirine analyzed by Plantamour is a Hornblende. Another mineral so called from the Island Skaadön, near Brevig, Norway, proves on analysis by Plattner (Pogg., lxxx, 315,) to be a pyroxene. According to Breithaupt it is black or greenish black to leek green, (the latter when in small crystals,) with a greenish-gray streak; cleavage brachydiagonal, perfect, macrodiagonal distinct; parallel to M only in traces. G = 3·432—3·504. Calculation from a measured angle gives for M : M 86° 52′, the angle of pyroxene.

Breislakite.—The identity of Breislakite and Augite, has been proved by Prof. E. J. Chapman (Phil. Mag., xxxvii, 444, Dec., 1850) from a measurement of minute crystals detected by him in the Vesuvian specimens. They gave for P on the axis 106° 18′, M : M = 87° 10′.

Staurotide.—Crystals of Staurotide from Cheronice have afforded Kenngott (Min. Unters., i, 49) the following angles:—M : M (∞P) = 128° 57′; P(0P) : a ($\bar{P}\infty$) = 125° 36′; M : a = 137° 18′; M : e ($\infty\breve{P}\infty$) = 115° 39′. The last angle would give for M : M the angle 128° 42′, and for the vertical and horizontal axes the relation 0·676 : 1 : 0·480.

Chiastolite.—A rhombic prism of chiastolite of a peach blossom color, affording the angle 93° 30′ and specific gravity 3·10, gave E. Renou (Expl. Sci. de l'Algérie, Paris, 1848. 58, and Lieb. and K. Jahresb., 1849, 736) the following composition:

$\ddot{S}i$ 36·6 $\ddot{A}l$ 61·9

with a trace of magnesia and iron, which is the composition of Kyanite. It is from mica slate in the vicinity of Bona.

Garnet.—A columbine-red garnet from Albernreit near Waldsassen in Bavaria, afforded A. Besnard (Correspondenzbl. Regensburg, 1849, iii, 30, Lieb. and K. Jahresb., 1849, 745)—

$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$
38·76	21·00	32·05	6·43	3·95=102·19;—G=4·2

Feldspar of the porphyry of Lessines and Quenast. Belgium: by A. Delesse, (Bull. Soc. Geol. de France, [2], vii, 310.)—The feldspar is in macled crystals belonging to the triclinic system; they are finely striated, of a white color or slightly greenish, with

a vitreous lustre. The greenish crystals are less hard and probably have undergone some alteration by infiltration. The mineral from Quenast afforded

S̈i	Ä̇l	F̈e	Ṁn	Ṁg	Ċa	Ṅa	K̇
63·70	22·64	0·53	*trace*	1·20	1·44	6·15	2·81, ign. 1·22=99·69

Delesse thence concludes that the feldspar is an oligoclase. The feldspathic paste of the porphyry contains some more oxyd of iron and magnesia than the crystals of feldspar, and Delesse distinguished minute crystalline plates disseminated through it, which appeared to be chlorite. The chlorite becomes of a bronze color after calcination.

The rock of Lessines affords crystals of axinite and epidote, besides quartz in crystals, and calcite. The porphyry taken as a whole afforded on analysis

S̈i	Ä̇l, F̈e	Ċa	Ṁg, alkalies,	Ḣ and C̈
57·60	25·00	3·23	9·92	4·25=100.

The proportion of silica is hence small, much below that of the oligoclase above described.

Analysis of Wollastonite from Auerbach, by F. L. Winckler, (Jahresb. f. pr. Pharm., xviii, 317,)

S̈i	Ċa and trace of Ṁg C̈	Ḣ	F̈e, Ṁn
53·0	45·40	1·0	0·6

On the Variolite of La Durance; by M. Delesse, (Ann. des Mines, 1850, [4], xvii, 116.)—The variolite consists of globules ordinarily of a whitish or greenish color, thickly imbedded in a green paste, and sometimes so densely aggregated as to exclude the paste altogether. The globules vary in size from half an inch to a point almost microscopic, and in the wear of the rock stand out on its surface. They are often of a violet shade within and have usually a somewhat radiated structure, concentric without, though at times containing minute disseminated white tabular crystals. On exposure they become a brownish or whitish kaolin. The paste is occasionally clouded in color or spotted serpentine-like. The specific gravity of the rock according to Delesse is 2·896; according to Brisson 2·934. In a similar rock from near Briançon the globules have a more uniform texture, and are imbedded in a blackish green paste. They are without cleavage and have a flinty fracture, G=2·923; which is above that of any known feldspar. The composition of these globules was found by Delesse to be—

S̈i	Ä̇l	F̈e	C̈r	Ṁn	Ċa	Ṁg	Ṅa	K̇
56·12	17·40	7·79	0·51	*trace*	8·74	3·41	3·72	0·24, ign. 1·93=99·86

They are properly therefore a feldspar, although it is difficult to determine certainly the species; as there is a euphotide in contact with the rock, Delesse suggests that it is probably the same with the feldspar of the Euphotide of Odern.*

* This Journal, [2] x, 252, and Ann. des Mines, [4], xvi, 323.

The green base, Delesse shows is not hornblende or diallage, but probably impure feldspar discolored by oxyd of iron and magnesia. The variolite of La Durance contains at times serpentine, and may be observed in some places graduating into this rock.

Variolite, euphotide and serpentine are usually associated in the same region. The mean composition of the rock from La Durance is

S̈i	Ä̇l	C̈r	Ḟe	Ṁn	Ċa	Ṁg	Ṅa	K̇	
52·79	11·76	*trace*	11·07	*trace*	5·90	9·01	3·07	1·16, ign. 4·38	=99·14

The rock is intersected by seams of epidote, quartz or carbonate of lime, and sometimes the globules are broken across by a vein and the two halves more or less displaced.

The glass formed from the variolite had the density 2·288, showing a great diminution from that of the unaltered rock, which is about 2·9.

This variolite receives a fine polish and is worked into ornaments of various kinds.

Orthite from East Bradford, Chester Co., Pennsylvania.—This mineral was sent by Mr. Thos. Seal, of Philadelphia, to Mr. J. D. Dana, and by the latter to Rammelsberg. Analysis afforded this chemist (Pogg. Ann., lxxx, 285)

S̈i	Ä̇l	F̈e	Ḟe	Ċe	L̇a	Ċa	Ṁg	
31·86	16·87	3·58	12·26	21·27	2·40	10·15	1·67, ign. 1·11	=101·17
Oxygen, 16·55	7·88	1·07	2·72	3·15	0·35	2·88	0·65	

This gives the oxygen ratio for the protoxyds, peroxyds and silica 9·75 : 8·95 : 16·55, and the formula $\dot{R}^3\ddot{S}i+\ddot{R}\ddot{S}i$, which agrees with the recent analysis of orthite by Rammelsberg, making the mineral analogous in composition to garnet.

Rutile.—The following are analyses of rutile by A. Demoly (Thèse de chemie, presentée à la Faculté des Sciences de Besançon, and Lieb. and K. Jahresb., 1849, 728):—

	T̈i	F̈e	M̈n	S̈i	
1.	96·41	1·63	0·13	1·83	=100
2.	96·45	1·62	0·14	1·79	=100
3.	96·43	1·62	0·11	1·84	=100

Brookite.—N. von Kokscharov has recently investigated the crystallization of Brookite of the Ural and the following are a part of the results obtained (Pogg. Ann., lxxix, 454):—M : M = 90° 50′ and 80° 10′. Angles of octahedron P, 101° 35′, 115° 43′, 111° 26′; of 2P, 87° 12′, 104° 54′, 142° 21′; of $\breve{P}2$, 135° 37′, 101° 3′, 95° 22½′; of horizontal prism, $2\breve{P}\infty$, 55° 48′ and 124° 12′: $\frac{4}{3}\breve{P}\infty$, 76° 55′ and 104° 5′; $\frac{1}{4}\breve{P}\infty$, 148° 39½′, 31° 20½′; $\frac{1}{2}\breve{P}\infty$, 121° 24½′, 58° 35½′; of vertical prism, $\infty\bar{P}2$, 45° 38½′, 134° 21½′. Specific gravity of the crystals according to Mr. Frödmann, 4·22.

On the Identity of Arkansite of Shepard and Brookite; by R. Hermann, (J. f. pr. Chem. l, 200.)—The identity of Arkansite with Brookite has been shown independently by J. D. Whitney, Miller, Rammelsberg, Breithaupt and Descloiseaux. Hermann confirms the previous measurement, obtaining the prismatic angle 100° 30′, and the octahedral angles 135° 30′, 101°, and 94°. His analysis afforded titanic acid 96·50, peroxyd of iron 1·00, protoxyd of uranium *a trace*, silica and gangue 2·50 = 100·00. Specific gravity = 3·79.

On Pyrochlore; R. Hermann, (J. f. pr. Chem. l, 185.)—The Brevig Pyrochlore analyzed by Wöhler is called Hydrochlore by Hermann, on account of its affording 7·06 per cent. of water. He applies the same name also to the Fredericksvärn crystals which gave Wöhler 4·20 per cent. of water, (with 62·75 metallic acids, oxyd of tin 0·61, peroxyd of cerium 6·80, protoxyd of uranium 5·18, Fe 2·16, Mn 2·70, Ca 12·85, alkalies *trace*.) [Adopting this plan of naming varieties containing water, without first ascertaining by extensive investigation that the water is essential to the original mineral, there will be no end to the new names to be coined.]

Another pyrochlore from Miask analyzed by Wöhler, he calls Fluochlore on account of its containing some fluorine. Hermann has analyzed the Miask pyrochlore and gives his former results anew as follows:

Niobic and ilmenic acids 62·25, titanic acid 2·23, zirconia 5·57, Ce 3·09, La 2·00, Y 0·70, Fe 5·11, Mn *trace*, Ca 13·54, K, Na, Li, 3·72, F 3·00, H 0·50 = 101·71. G. = 4·203.

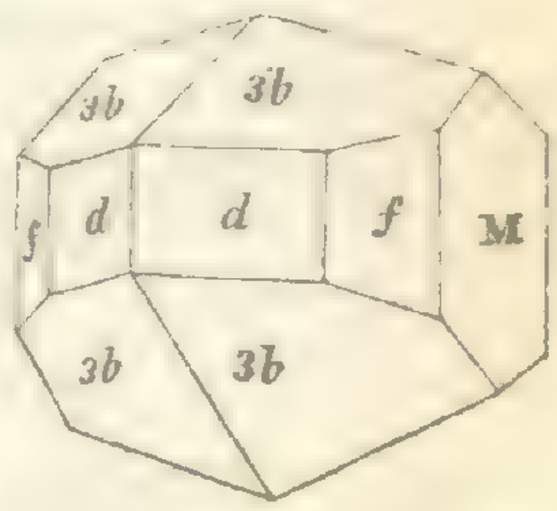
According to a more recent analysis by him it contains

Niobic acid 60·83, Titanic acid 4·90, Ce and La 15·23, Y 0·94, Fe 2·23, Ca 9·80, Mg 1·46, K 0·54, Na 2·69, F 2·21 = 100·83.

[It is well known that fluorine enters into the constitution of certain micas and other minerals, in some of their varieties, and yet is not essential to the species. There is therefore no propriety in assuming in the above case that the fluorine variety of pyrochlore is a distinct species or is worthy of a distinct name.]

Mengite; Hermann, (J. f. pr. Chem. l, 179.)—Breithaupt remarks that the angle of the prism of Mengite (*d*) 136° 40′, is identical with a prism of columbite. Another prism (*f*) gives 100° 28′, and the rhombic octahedron (3*b*) has the angles 150° 32′, 101° 10′, 86° 21′. According to Rose it is a zirconia mineral, and it is therefore an example of isomorphism.

1.



On Yttroilmenite and Samarskite; by R. Hermann, (J. f. pr. Chem. l, 164, No. 11, 1850.)—Hermann still sustains his view that yttroilmenite contains the acid of a new metal *ilmenium*, con-

trary to the investigations of Rose. In an analysis of Samarskite he obtained

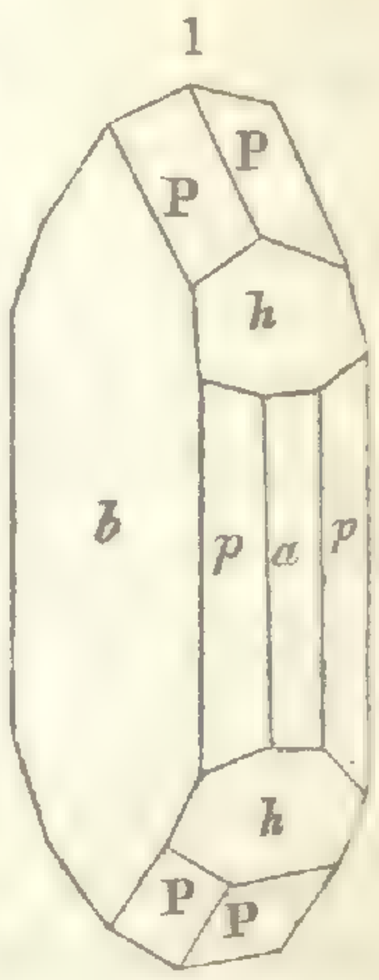
Niobic acid with a little ilmenic 56·36, U̇ 16·63, Ṁg 0·50, Ṁn 1·20, Ḟe 8·87, Ẏ 13·29, Ċe, L̇a 2·85=100·03.

According to which it is a niobate of protoxyd bases. Color of specimen black, with partly a grayish-brown crust. G.=5·64.

On Æschynite; by R. Hermann, (J. f. pr. Chem. l, 193.)—Hermann has reänalyzed Æschynite and found it to consist of

Niobic acid, 33·20, titanic acid 25·90, C̈e 22·20, Ċe 5·12, L̇a 6·22, ẏ 1·28, Ḟe 5·45, Ḣ 1·20=100·57.

Polycrase and Polymignite, (Hermann, J. f. pr. Chem., l, 181.)—The angles of polycrase are as follows, according to Scheerer and Hausmann's calculations: octahedron P, 152° 0′, 90° 2′, 96° 41′; vertical prism (*p*) 140°; brachydiagonal prism (*h*) 56° 0′. Hermann observes that if the crystals be viewed in a different position, the angles approach those of columbite, in which P=150° 17′, 86° 52′, 100° 49′; brachydiagonal prism (corresponding to vertical above) 123° 50′ to 125° 20′; macrodiagonal prism (corresponding to brachydiagonal above) 139° 6′. Although the composition is widely different from that of columbite, the two minerals are approximately isomorphous.



Polymignite is related crystallographically in the same manner to columbite. The three prisms of 70° 50′, 109° 10′ and 140° 51′ in Polymignite, correspond to three prisms 70° 50′, 109° 35′, 141° 8′, in columbite. To perceive the relations between the crystals of the two minerals, the vertical prisms of polymignite, as the mineral is usually drawn, should be compared with a series of horizontal prisms in columbite.

Hermann also remarks that Brookite approaches columbite in its angles.

Hermann adopts the view that tantalic and the related acids contain 2 of oxygen like titanic acid; and he concludes also from the isomorphisms observed, that zirconia is a protoxyd, urging that it does not replace alumina while it does replace protoxyds. Mengite he makes a titanate of protoxyd of iron and zirconia; polymignite a titanate of the same with yttria; polycrase a titanate and tantalate of protoxyds of zirconium, iron, uranium, cerium; yttroilmenite an ilmenate and titanate of protoxyds of yttrium, iron and uranium; columbite a niobate, pelopate or ilmenate of protoxyds of iron and manganese (3 of acid to 2 of base.) He also concludes that Wolframic acid has the formula $\ddot{W}$ and not $\dot{\ddot{W}}$, on the ground that Wolfram ($\dot{R}\,\ddot{W}$) is isomorphous with columbite. [This last case of isomorphism ap-

pear to be set aside by Descloiseaux's measurements which make Wolfram *oblique* in crystallization.]

Red Antimony.—Kenngott has examined crystals of this mineral from Bräunsdorf, (Min. Untersuch., i, 1, Breslau, 1849, and Liebig and Kopp's Jahresb., 1849, 727,) and obtained for the inclination of the vertical axis to the terminal plane (0P) 77° 51′; 0P : ∞P∞ = 102° 9′; 0P : P∞ = 149° 46′; two planes (P∞, and $\frac{1}{3}$P∞) incline to the vertical axis at angles of 37° 37′, and 71° 55′.

Titaniferous iron.—Vast deposits of titaniferous iron have been found by Mr. T. S. Hunt about the bay of St. Paul, Canada. One mass is 90 feet in breadth and 300 long. The masses are imbedded in a syenitic rock. The ore is massive and often coarsely granular. Color and streak black. G. = 4·56—4·66. H. = 6. Feebly affects the magnetic needle. Analysis gave

Oxyd of Titanium 48·60, Protoxyd of Iron 46·44, Magnesia 3·60=98·64.

The iron was principally in the state of protoxyd, but a portion was in the state of peroxyd and to this the deficiency in the analysis is attributed.—*Logan's Rep. Geol. Canada*, 1850.

Triphyline.—The Triphyline of Bodenmais has been analyzed by Baer (Arch. Pharm. [2], lvii, 274, and Lieb. and K. Jahresb., 1849, 773) with the following result:

P̈	Ḟe	Ṁn	Ċa	Ṁg	K̇	Ṅa	L̇i	S̈i	
36·36	44·52	5·76	1·00	0·73	1·19	5·16	5·09	1·78	=100·59

Supposing the silica in combination with part of the protoxyds as Ṙ³ S̈i, the analysis affords the ordinary formula of the species Ṙ³ P̈. After heating, the mineral dissolves in acids and becomes brownish red.

Humboldtine or Oxalate of Iron.—This species has been detected by Mr. T. S. Hunt at Cape Ipperwash, Canada, in shales; it occurs as a soft earthy coating or incrustation of a sulphur yellow color. On heating, it instantly blackens, becoming magnetic, and then changes to red. The shales contain species of calamites, which tends to confirm the opinion that its formation is of vegetable origin.—*Logan's Rep. Geol. Canada*, 1850.

On Beudantite; by John Percy, M. D., (L. E. and D. Phil. Mag., [3], Sept., 1850, xxxvii, 162.)—Dr. Percy confirms the conclusion of Damour and Descloiseaux, (Ann. Ch. Phys., [3], x, 73,) that Beudantite is Cube ore, although quite impure. In his analyses he obtained

	S̈	Ä̈s	P̈	Ḟe	Ṗb	Ḣ	
1.	12·31	9·68	1·46	42·46	24·47	8·49	=98·87
2.	12·35	13·60	*undetermined*	37·65	29·52	8·49	=101·61

Owing to the small quantity under investigation Dr. Percy observes that these results can be considered as only approximate. The determination of the arsenic acid in the second analysis is

probably somewhat in excess. He infers that the mineral is cube ore (or arsenate of peroxyd of iron) containing as impurities sulphate of lead and sulphate of iron.

Copper-Mica of Andreasberg.—Rammelsberg (Pogg. Ann., lxxix, 465) has examined this mineral, before investigated from a different locality (Ockerhutte) by Beneke (Pogg. Ann., xli, 333) and Borchers, (ib., p. 335,) and first mentioned by Hausmann and Stromeyer, (Schw. J., xix, 241,) and has confirmed the analysis of Borchers. It occurs mixed with black copper in gold-yellow mica-like scales, which separate on subjecting the mass to dilute nitric acid. The results of Rammelsberg and Borchers are—

	O	Cu	Ni	Sb
1. Rammelsberg,	18·31	34·63	23·00	22·40=98·34
2. Borchers,	18·67	35·16	23·97	21·06=98·86

or

Ċu	Ṅi	S̈b
43·38	29·23	26·57
44·28	30·61	25·11

giving the formula $\dot{R}^{12}\ddot{S}b$. Specific gravity 5·783.

Black oxyd of Copper of Lake Superior.—Rammelsberg states (Pogg., lxxx, 287) that this ore afforded Mr. Joy, of Boston, in his laboratory, in a pure specimen, 99·45 per cent. of oxyd of copper; another specimen gave besides oxyd of copper—

1·19 F̈e, 0·23 Ċa, 3·38 S̈i.

Chalcotrichite (*Kupferblüthe*).—Kenngott (Min. Unters., p. 31, and Lieb. and K., p. 727) describes crystals of chalcotrichite or the capillary red copper, both from Nischne-Tagil and Rheinbreitenbach, which pertain to the trimetric system. They occur in rhombic prisms of 140 to 150 degrees with the edges truncated. This oxyd of copper appears therefore to be trimorphous.

Tin Ore and Gold from Wicklow.—The tin ore occurs with gold at the stream-works in the county of Wicklow. W. Mallet obtained on analysis (Trans. Geol. Soc., Dublin, and Phil. Mag., xxxvii, 392) Peroxyd of tin 95·26, peroxyd of iron 2·41, silica 0·84=98·51. Platinum is reported from the same region, besides sapphire, topaz, zircon, molybdenite, wolfram, pyrites and other iron ores, &c.

The gold afforded Mr. Mallet, Gold 92·32. silver 6·17, iron 0·78=99·27, equivalent to $8\frac{1}{4}$ atoms of gold to 1 of silver. Sp. gr. =16·342.

Irite.—Crystals of Irite in regular octahedrons have been observed by Kenngott (Min. Unters., i, 61).—They are much flattened parallel to one of the faces. The true formula of the species is probably included under $\dot{R}\ddot{R}$, which embraces the spinels, magnetic iron and some other tesseral species.

Note.—Errata in the writer's Mineralogy, third edition.—p. 45, 9th l. from bottom, for *m′ n′ P* read *m′ P n′*.—p. 209, Arragonite, anal., for F̈e Ḧ read F̈e² Ḧ³.—p. 211,

Note.—We add here the following notice communicated for this Journal :—

On the Vanadium Minerals from Lake Superior; by James E. Teschemacher.—The surface of the large masses of copper found in the celebrated Cliff mine, on the border of the lake, is sometimes encrusted with thin layers of small crystals of quartz, interspersed with a yellow pulverulent substance resembling peroxyd of iron. On exposing small pieces of these layers to the action of the blowpipe, this yellow powder turns black. Pulverized with the quartz and boiled in dilute nitric acid gives a very light apple-green solution; this powder so treated, washed, filtered and evaporated to about the amount of the water used in washing, was left untouched for about a month, when minute crystalline red globules began to form on the surface, which fell to the bottom, when by aggregation they became sufficiently heavy. The form of these crystals could not be determined even by the microscope, the crystalline points were so numerous and in such apparent confusion. From these red crystalline masses, the writer, as well as Dr. A. A. Hayes, produced the vanadiates of silver and lead. No metal having been found in the solution, it is probable that the yellow powder exists here as vanadic acid, VO^3.

The chocolate-colored earth from Isle Royale is quite a different mineral. After a few preliminary trials, the following process was adopted. The pulverized mineral was digested a short time in dilute nitric acid; from this a light blue solution was obtained, showing the separation of a small quantity of copper, although great care had been taken in the separation of the mineral from the mass of copper it invested. After washing with a small quantity of hot water and drying, the deeper red colored powder was boiled in dilute hydrochloric acid, washed with a small quantity of hot water and dried. The result of this separation of a considerable proportion of iron was a very light grey-

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anal. 16, before 2·25 add Ḟe, and for No. 21, 22, 23, before the analyses, read 22, 23, 24.—p. 213, Hydromagnesite, anal. 1, for 0·27, read 0·57, and for 1·66 read 0·27. —p. 226, 21 and 27 l. from top, for Ṁn, read M̈n.—p. 250, anal. 7, for 19·342, read 18·342.—p. 252, anal. 6, for 4·83, read 3·83—p. 293, anal. 8, 9, 10, for Ḟe, read F̈e.—p. 294, anal. 11, 12, 13, for M̈n, read Ṁn.—p. 299, last line, dele "laumonite (Damour's) and."—p. 303, anal. 2, for 33·70, read 22·70.—p. 309, anal. 20 is by Mr. Anderson.—p. 310, anal. 1, Haydenite, for 0·27, 0·25, read 2·70, 2·50.—p. 316, anal. 11, for 56·111, read 54·111.—p. 339, 20 l. from top, for Mexico, read Sterling, Mass. —p. 353, 16 l. from top, for 22, read 23, and anal. 27, for 13·25, read 18·25.—p. 361, anal. 3, for 3·15, read 4·15.—p. 362, anal. 3, for 51·50, read 51·20; anal. 5, for 0·92, read 0·72, and for 100, read 100·46; anal. 6, for 100, read 100·10; 7th line from bottom, for 3Ḣ read 9Ḣ.—p. 366, anal. 5, 6, 7, for H F, read F.—p. 367, anal. 3, for H F, read F.—p. 371, anal. 6, add S̈i 5·59.—p. 381, Thorite, for Z̈n, read S̈n.—p. 382, anal. 11, for Ḃe 4·50, read Ḃe 3 50.—p. 595, Æschynite, anal. 2, 3, for C̈e, read Ce.—p. 401, anal. 3, for 69·62, read 79·62; anal. 9, for 0·2, read 2·0.—p. 679, Tritomite, anal. for C̈r, Ḟe, Ca, read C̈e, L̇a, Cu.—p. 689, last line, dele 3 before R̈³ S̈i.—p. 694 Rensselaerite, anal. 1 and 2, add, Ṁg 32·90, Ṁg 25·20. J. D. D.

colored powder. This was heated to redness in a silver crucible with caustic potash; prior to red heat combination took place with some violence, and on boiling with water a grey flocculent precipitate went rather rapidly to the lower part of the filter, which was washed with a little boiling water. This precipitate on drying changed to a dark-grey color. Before the blowpipe with borax, in the reducing flame, this gave a clear globule, yellow while hot, fine green while cold, producing these changes as often as desired. A small portion boiled in nitric acid, dried and exposed to the blowpipe alone on the platina wire, fused into brick-red globules, but on urging the reduction flame, after a little time these globules fused together with a brilliant light and left a grey porous mass. These actions before the blowpipe are characteristic of vanadium. If only a minute quantity of the grey powder is used, the bead is yellow while hot, but the green color is scarcely visible.

After separating the grey powder, hydrochloric acid was added to the filtered liquor in excess. Evaporated to dryness, silica was separated; but previous to drying there appeared a small quantity of grey powder, which, after twenty-four hours' exposure in water to the air, changed to a distinct green color. This is probably the silicate of vanadic oxyd, and it passed in solution through the filter; it is almost impossible to separate it from the silica, which was again fused for a considerable time with the caustic potash and separated by hydrochloric acid. The silica was now mixed with a number of colored grains, which, under the microscope, varied from a transparent red to a dark black, and were probably VO^2 and VO^1, combined with the silica. From the washing a small portion of alumina was afterwards separated by ammonia. From the absence of all metals except iron and the minute quantity of copper before mentioned, it is probable that the mineral here is in the state of vanadic oxyd VO^2. I regret that my stock of this interesting mineral is so nearly exhausted as to preclude any farther investigation, but as it must exist there in abundance, and the vanadic oxyd seems to me to amount to at least 20 per cent., I trust we shall not be long without more knowledge on this subject. On igniting the vanadiate of ammonia from the first mineral in a platina capsule, a combination with the platina took place, forming a dark bluish-black stain which could only be removed by scraping; this made me cautious in using platina vessels. The combination with silica would probably render the process in question useless for quantitative analysis.

Art. XXVIII.—*Notices of Coal in China ;* by D. J. Macgowan, M. D., Cor. Mem. of the Asiatic Society of Bengal.*

Coal deposits exist to a greater or less extent throughout the different mountain ranges which girt the great plain of China. On its northern boundary this mineral is met with in numerous localities, on the Celestial Mountains, on the Mongolian steppes, and various offsets of the Altai range, the most productive of which are in Shingking and Shánsí. There are several smaller deposits in Chihlí and Corea. Unskillful mining, and the want of suitable means of transport, enhance the cost of the mineral, and limit its consumption. Except for culinary and manufacturing purposes, it is little used, the inhabitants trusting to furs and skins for protection from the extreme rigor of their winters.

The best coal brought to the capital, is from Pingting chau in Shánsí. Anthracite of good quality is brought from Káichau in Liáutung. Chinese cosmogonists, drawing on mythology, gravely state, that in one of the Pingting mines the furnace still exists, in which Niúkwa fused stones for repairing holes in the heavens, and that it is the original of furnaces now in use. Those deposits which have been mined for the longest period, with which we are best acquainted and are the most productive, lie in the middle and southern parts of the empire.

That branch of the Himalayan range, known as the Yun-ling, forming the prominent topographical feature of the provinces of Sz'chuen, Yunnán, Kweichau, Húnan, Kwángtung, Fuhkien, Kiángsí, and Chehkiáng, has the carboniferous system superimposed on a granitic base through a great part of its extent, in numerous sections of which the coal measures exist, generally interstratified with beds of slaty clay and limestone. Those best known lie in the basin of the Kán in Kiángsí, reposing on old red sandstone and gray compact limestone, in close connection with deposits of iron ore. Those in the valleys of the Siáng, Tsz', and Yuen in Húnán, the west slope of the terminal ridges of the Yun-ling in Chehkiáng, at the sources of the Tsientáng, and the southern aspect of the same range in Kwángtung at Nánhiung, all present analogous geological relations. This vast carboniferous tract appears to be continuous in a measure with that of Assam and Burmah.

The coal most in demand in central China is called "the Kwang coal." It is brought from various districts in Húnán. Súchau is the entrepôt for all that is consumed in Kiángsú and Chehkiáng. It is black, very compact, specific gravity 1·34, columnar structure occasionally iridescent, and from the large quantity of carbon

* Chinese Repository, vol. xix, July, p. 385, 1850, No. 7.

it contains is analogous, though inferior to the American anthracite ; it burns intensely with a small blue flame, its ashy residuum being of a reddish color. That in use at Sháughái is of this description. It is brought from Súchau, via Chapú to Ningpo, where it costs $12 per ton, about one third more (the dealers say) than at Sháughái. Its consumption is very limited, being almost wholly confined to the manufacture of brass tobacco pipes. The best quality of this coal, that which most resembles anthracite, is well adapted for grates and stoves, being free from fumes of sulphuretted hydrogen, and is more wholesome than the bituminous coal usually imported from Liverpool and Sydney.

Numerous varieties are produced in the province of Kiángsú, slaty, cannel, bituminous and anthracite. Portions of the latter are sold at Súchau as the *kwáng* coal. A considerable quantity from the mines in Kwángsin is carried over the mountains into the province of Chehkiáng. It is found abundant also in Fungching and Chingkiáng. The proximity of the coal measures in this province to ferruginous ore and lime, facilitates the manufacture of iron. Some of the mountains which support the subterranean treasures, afford disintegrated granite, of which the celebrated porcelain is fabricated. The furnaces in Kingteh-chin, the great seat of this branch of industry, are chiefly heated by coal procured from adjacent mines. The generic designation for the mineral produced from the Chehkiáng mines, is Kiángshán coal, the name of the district in Küchau fu, in the S. W. part of the province, whence it is chiefly derived. A large quantity however comes from the conterminous districts of Síngán, and Chángshán. The principal mines are at the Wúkwei mountain, near Kítung, and at the Chenkiá lake in the first named district. There are several varieties, that most valued is termed " wood coal ;" it exhibits, where it is laminated with the fibres of the bituminated vegetable, a distinct, bright, conchoidal fracture ; at all other points it presents a dull, coarse-grained, segregated texture. Specific gravity 1·29. It burns with some smoke, and cakes ; emitting a small quantity of hydrogen gas, leaving light colored ashes. It possesses a much larger proportion of carbon than ordinary bituminous coal, and some specimens compare very favorably with that brought from England, and stored at Ningpo for H. B. M. steamers ; yet generally speaking, the coal found on this continent is unfit for the steam engine, that from the island being better adapted for such purposes. One of the varieties is called *iron coal ;* " it is slaty, and can be ignited only with the aid of the bellows ; another is the *Barbarian coal*, which burns rapidly, with a large amount of smoke, and resembles brown coal. The peculiar properties of other varieties are designated by their names as " stinking coal," " crackling," and " smoky coal ;"—an inferior quality comes from one of the mines, abounding in sulphuretted hydrogen, and closely resembles the coal found near Canton.

The "wood coal" is generally reduced to powder, and formed into cakes with mud, and employed in furnaces for culinary purposes, and in chafing dishes for warming public offices. It is used to some extent by blacksmiths. Coal cakes are much used at Hángchau, in the liquor shops, in order to keep warm rice-whiskey on hand at all hours of the day; and in the tea shops, where boiling water is in constant requisition. The furnaces are certainly primitive, consisting of a few bricks making a close square or circular chamber, generally about four inches in diameter with a small grate below, and inclosed above. When the cakes are perfectly ignited by a few chips, and the smoke ceases to rise, the top is covered with mud, through which, before drying, an orifice is pierced half an inch in diameter. The vessel containing whiskey is then placed over the hole, and is thus kept hot all day without further care, at a cost of a cent and a half. The same rude apparatus, with slight modifications, is in general use wherever coal from its proximity is not expensive. Sometimes the brickwork is inclosed in boards, elaborately carved and varnished. Were grates or fire-places constructed with suitable flues and chimneys, coal would be found a more useful article, be in great demand, and the mines consequently be better worked. Even the miners find it more convenient and cheaper to burn the shrubs and grass of their sterile hills than the coal they dig from their bowels.

Twenty thousand tons of coals are annually brought from these mines to Hángchau, which at the hills cost $5.75 per ton; the baskets in which the mineral is packed bring the cost up to $6.50; and the expense of transportation to Ningpo raises it above $8 per ton. The annual production and value of the Chehkiáng coal mines may be computed with considerable accuracy, and thus afford data for a national estimate, which may be thus given:

Chehkiáng, - - - - - - -	60,000 tons.
Kiángsí, - - - - - - -	160,000 "
Húnán, - - - - - - -	230,000 "
Northern Provinces, - - - -	280,000 "
Kwángtung and Western Provinces, -	100,000 "
Total, - - - - -	$20,000 "

This portion of the mineral wealth of China may be computed at nearly six millions of dollars. The paucity of the supply is owing not to the poverty of the mines, but chiefly to the want of those facilities for mining, which the steam-engine alone can supply. Mines often, when they become most productive, are suddenly filled with water and rendered useless. In this manner an immense number of shafts of great extent are unavailable. Provided with the steam-engine and the safety lamp, the Chinese miner could doubtless bring to light inexhaustible supplies of this subterranean treasure.

Chinese miners are extremely poor and rude mountaineers; it is said they often relieve hunger by eating coal, and if it be true, as has been represented, that pigs fatten on this mineral in some western countries, this report respecting Chinese miners is not incredible. For the most part, the mines are worked in horizontal shafts, though pits are sometimes dug. At one period, powdered coal was mixed with flour and the juice of dates, and burned in chafing-dishes for producing a fragrant perfume. For such pastils, charcoal has been substituted. This mineral, the source of so much wealth and power in the West, does not appear to have been known to Europe more than three hundred years, but Chinese antiquarians refer its use to a remote period in their history. Its utility in the arts has been appreciated at Peking for more than a thousand years, as may be inferred from the encomiums bestowed upon it by a poet of the Sung dynasty, who lauds it as useful in the manufacture of iron implements. A writer in the early part of the seventh century mentions the article. The earliest notice of coal is in the history of the Hán dynasty, B. C. 202 to A. D. 25, where the remark occurs that Kiángsí produced stones, which were used as fuel.

To appreciate rightly the value of these vast coal deposits, extending from Corea to Siam, regard must be had to the increasing commerce of the Pacific, to the revolution which seems on the eve of taking place in the route of communication with western nations, and to the prospective greatness of the Anglo-Saxon states springing into existence on its eastern shores. Of their capacity, aided with the appliances of foreign skill and capital to supply all demands which the steam-engine may make upon them, both for manufactures and navigation, there can exist no doubt.

Nor have these primeval forests been stored upon the continent alone; they abound in more accessible situations, isolated, as it were expressly for steam navigation, in the islands of Japan, Formosa, and Borneo. Before the application of steam and coal to navigation, a skeptical philosophy might have questioned the utility of deposits of this mineral in the torrid zone, and immediately under the equator; but the design of the Omniscient Artificer of this beautiful sphere is now obvious, affording another evidence that He left nothing to fortuitous circumstances: it is another lesson fraught with instruction for reflective minds. May the name of the immense sheet of water, on whose shores Infinite Beneficence has scattered this mineral, indicate the peaceful purposes of all who traverse it, that both elements may contribute to the diffusion of commerce and civilization in fusing hostile races into a common brotherhood!

Ningpo, February 1st, 1850.

ART. XXIX.—*Abstract of a Meteorological Journal kept at Marietta, Ohio, for the year* 1850, Lat. 39° 25′, Long. 4° 28′ west of Washington; by S. P. HILDRETH, M.D.

MONTHS.	THERMOMETER. Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Inches of rain and melted snow.	Winds.	BAROMETER. Maximum.	Minimum.	Range.
January, - -	29·13	58	1	13	18	5·25	S. W. & S. E.	29·80	28·85	·95
February, -	34·33	64	2	12	16	3·41	S., S. W. & N.	29·98	28·56	1·40
March, - -	39·11	66	9	13	18	4·50	S. E., S. & N.	29·70	28·65	1·05
April, - -	48·11	80	22	16	14	3 17	N., S. & S. E.	29·70	28·65	1·05
May, - -	55·81	86	32	23	8	3·25	S. W. & N.	29·60	28·98	·62
June, - -	69·27	88	39	26	4	4·84	S. W. & N.	29·70	29·25	·45
July, - -	76·14	92	60	27	4	4·41	S. & S. E.	29·45	29·25	·20
August, - -	71·77	89	50	23	8	6·91	S. — N.	29·60	29·20	·40
September, -	63.33	84	40	26	4	4·66	S. — N.	29·64	29·10	·54
October, - -	51·48	81	27	22	9	2·54	S. W. & W.	29·60	29·10	·50
November, -	44·68	75	18	18	12	2·42	S. S. W. & N.	29·60	29·15	·45
December, -	34·66	65	10	14	17	7—	S. W. & W.	29·75	28·45	1·30
Mean for year,	51·48			233	132	52·36				

THE mean temperature for the year 1850 is 51°·48, which is somewhat less than that of 1849, being 52·09. This depression may be found in the low grade of the spring and autumn months; the mean for this year being nearly five degrees less in the spring than that of 1849, while autumn is about one degree below. The summer was warmer by about one degree and a half. The greatest heat was in July, the mean for that month being 76°·14, while July of 1849 was 72°·20.

The mean temperature of the winter was 31°·53, being almost three degrees less than the preceding one. It was not remarkable for any excesses in temperature, or depth of snow;—at various times, there fell during the winter seventeen inches; ten was the greatest fall at one time; it took place on the 13th of January, but soon melted away. The Muskingum river was frozen over on the first day of January, and remained closed for fifteen days. Ice was formed about three inches in thickness, affording a scanty supply for the ice houses. In the Ohio river there was much floating ice, but not so abundant as to stop the running of steamboats. The temperature was at no time below zero, but stood at one above on the first day of the year. There was a large quantity of rain in January, over five inches, and at one time the rivers threatened an overflow of their banks. February usually furnishes the coldest weather of any of the winter months, but this year the mean was five degrees above January. The mean of one day, the fourth of this month, was below that of any other, being only eight degrees, while the lowest in January was thirteen.

The mean of the spring months was 47°·68, which is nearly 5° below that of 1849. The cold backward weather of March and April, retarded the blossoms of fruit trees so much, as in a measure to guard them against late spring frosts, which in southern Ohio, is the greatest drawback to the fruit-grower. The consequence was a full and fine crop of fruits of all the usual varieties, and of the best quality. A severe drought the last of May and early part of June, at one time threatened the total destruction of the corn, oats and potatoes, it continuing nearly a month without rain. But a full supply the last of June, put all right again. This drought, however, was very favorable to the wheat crop, ripening it without rust; a disaster certain to befall it if the weather is wet and hot when the grain is in the milk or immature state.

The mean of the summer months was 72°·39, being nearly a degree and a half above that of the preceding year. This warm weather was exceedingly favorable to the ripening of fruits, especially melons, which were in great perfection; also to the growth of sweet potatoes, which have become an important crop, with some of our farmers, especially near the large towns. It also suited the grape, which is a valuable article of culture. A serious evil, however, has begun its ravages on this delicious fruit, namely, the grape Curculio, which threatens to be disastrous to its future prosperity. Two or three years ago, it was first noticed in this vicinity. I have several of its larvæ in a pot of earth, intending to study its economy and habits.

The temperature of autumn, was 53°·16; being more than a degree less than in 1849. Severe frosts did not appear, till the 29th October, when Dahlias were first killed.

Floral Calendar.—March 19th, First robin, heard; 21st, Black birds; 23d, Blue bird; 31st, Hepatica triloba in bloom—Early Hyacinth.

April 7th, Apricot in bloom; 21st, Service tree; 22d, Peach tree; 23d, Imperial gage and prune; 24th, Sanguinaria canadensis; 27th, Pear; 28th, Ranunculus virosa; 29th, Pyrus Japonica —very late this year, usually a week before the Pear tree; 30th, Cherry.

May 2d, Apple tree in bloom; 4th, Judas tree: 6th, Cornus Florida: 8th. Chickasaw plum; 11th, Tulips; 12th, Hickory tree; 16th, Quince; 19th, Lilac and Black Haw; 20th, Purple mulberry; 23d, Viburnum; 28th, Syringa fragrans.

June 1st, Locust tree—very late; 2d, White peony; 4th, Hudson strawberry ripe; 6th, Kalmia latifolia in bloom; 10th, Syringa Philadelphica; 13th, Catawba grape in bloom; 22d, China ailanthus; 23d, Purple mulberry ripe; 25th, Magnolia glauca in bloom; 27th, Catalpa; 28th, Early wheat ripe.

July 2d, Red cherry ripe; 4th, Red Antwerp raspberry ripe; 15th, Blackberry ripe.

ART. XXX.—*On the different Chemical Conditions of the Water at the surface of the Ocean and at the bottom, on Soundings;* by AUG. A. HAYES, Assayer to the State of Mass.

CONSIDERING the surface, which the ocean covers in comparison with any large extent of land surface, we might be led to expect a want of uniformity in the distribution of saline matter throughout its mass. Those parts reposing in immediate contact with saline deposits and many decomposing rocks, would every instant receive more soluble matters than contiguous portions, and while matter to be dissolved remained, the balance of distribution would be disturbed. Local differences are known to exist and are referred to the influence of evaporation, and to lower and upper currents, with great degree of probability. Still, the belief that the water of the ocean has existed during the lapse of great geological periods of time, with the same or even a large proportion of saline matter, must gradually give way, as facts connected with the decomposition of rocks are attentively studied.

The phenomena which form the subject of this communication, are only remotely connected with this point of unequal distribution; being related to *kind*, rather than quantity of saline parts.

The mass of ocean, exposed on its surface to the mixture of gases forming our atmosphere, absorbs both constituents, the oxygen in the larger proportion. Winds greatly favor this effect, and the increased quantity found in the water after storms, is referred to this action.

When ocean water, taken at the same moment from the surface and only one to two hundred feet under this surface, is subjected to the usual course of analysis, a larger proportion of oxygen is constantly found in the surface samples. Trials, made at points from the temperate to and within the torrid zone, corresponded, and only slight deviations were found in the moving water of the Gulf Stream. Another kind of evidence of this fact, is afforded by the observations made on the corrosion of the copper sheathing of vessels. Slight inequalities in the kinds of copper used exist; but when a large number of cases are included and time of observation is considerable, this influence is hardly seen. It is a general law, that copper sheathing corrodes most rapidly at those parts of the covered surface, where, by agitation, the most air is dissolved in the water passing in contact with it. The fact is well known, that sea-water, deprived of air, has no action on copper even after many years' exposure, and this relation becomes changed, when we allow the same water to dissolve air. Some persons who have noticed this uniformity of corrosion, at

the points where the water contains the most dissolved air, have attempted an explanation, on mechanical principles. They have assumed that greater friction between the moving surface and the water takes place at those points. It is not uncommon for vessels to make long voyages and return with the *chalked numbers of the sheets legible*, and active corrosion *seldom* takes place on those parts of the coppered surface, really exposed to the greatest friction.

If we assume that the oxygen of sea-water is almost wholly derived from solution of one part of the atmosphere, then the surface under existing conditions should contain the largest amount. The organized beings of the ocean, consuming the oxygen as diffused, would constantly diminish the quantity below and allow an inequality to exist.

The reactions taking place in the corrosion of copper by the surface water of the ocean, considered in all their particulars, become quite complex. Without entering minutely into these, it is sufficient to adopt the usual expression, that the oxydation and corrosion of copper take place in consequence of the decomposition of hydrochlorates, under the presence of oxygen and metal; a very common change, resulting in the production of oxyds and chlorids.

While pursuing the subject of copper corrosion at the surface, I was some years since led to examine samples of copper, which had remained some time at the bottom of the ocean. In these cases an opposite kind of action was at once recognized, and the observations have been so far multiplied, that I think a constancy of result will be observed in all cases on soundings.

Copper and bronze, and even a brass compound, were found thickly incrusted with a sulphuret of copper, formed often in crystallized layers, having a constant chemical composition, entirely free from chlorine or oxygen, the corroding agents of the surface. Specimens of copper and bronze from mud and clay at different depths, and in one instance from clean sand below a powerful rapid, have given thick layers of sulphurets of copper, or copper and tin.

These observations have been lately extended, and as they include other materials, I shall state them more particularly.

The Spanish vessel San Pedro de Alcantaro, was blown up off the coast of Cumana, in the year 1815, and a large amount of specie dispersed and sunk. A large part of the silver dollars has been recovered during the past year, by our enterprising countrymen, from a depth between fifty and eighty feet. The coin reposed in mud and was sometimes covered by a stratum of coral, from six to twelve inches thick.

Two pieces of the coinage of 1810 and 1812 were taken for analysis. The weight of such dollars, slightly worn, was 412

grs. nearly. When the coin of 1810 had lost its covering, it weighed 330 grains, or 82 grains of the substance of the dollar had assumed the state of a sulphuret. The other weighed 356·82 or less by 55·18 grs. By exposure during thirty-five years in one case, 100 parts of the coin had been destroyed to the extent of nearly 20 parts, the other 13·39, giving an average of 16·52.

These incrustations were crystallized distinctly and their composition was carefully determined. Water abstracted traces of chlorids of sodium and magnesia, with sulphate of lime only. Acetic acid took up a compound of chlorine, carbonate of lime and oxyd of copper, in minute quantity. The investing coating was removed from one coin by making it the negative of a single galvanic circle, in dilute sulphuric acid, so as to obtain the covering in sheets; a loss of sulphur taking place. Water acidulated with nitric acid, after several days, detached the covering from the other, and this sample was used for determining the sulphur, in the form of sulphuric acid, as well as the bases. Operating in this way, it was found that very small portions of chlorids of sodium, magnesium, and sulphate and carbonate of lime adhered to the incrustation, while the pure portion of this consisted of bisulphuret of copper with sulphuret of silver and gold; even the minute trace of the latter metal in the silver, being mineralized by sulphur.

Connected with this observation is another I have made on the corrosion of an alloy of 1 silver in 500 copper, used as sheathing, in which both metals united to chlorine and oxygen, and were removed rapidly and largely by surface water, as a simple metal would have been.

No opportunity has yet offered for continuing these examinations on copper and other metals obtained from great depths of water; and in calling the attention of chemists to this action, I hope to obtain results from those who are more favorably situated for observation.

The opposite tendencies of the two parts of the ocean on soundings being shown, a large mass, distinguished as "green water," is really placed as it were between the poles of a gigantic single galvanic circle, and we are thus enabled to explain many anomalous decompositions taking place within such limits.

In looking for the cause of the transfer of sulphur from its oxydized state, in saline compounds, to the metals on the bottom of the ocean, I have concluded that the waters from the land, exert a most important influence. These waters are never destitute of organic matter in a changing state. This matter dissolved from the surface of the earth or from rocks in percolating the strata, assumes a state in which it powerfully attracts oxygen. Waters holding this matter in solution, readily decompose sul-

phates of lime and soda, even when partially exposed to atmospheric air. The line at which the saline waters of the ocean and the under-land flow of water meet, is the place, where observations have shown that the greatest chemical action exists. Ordinary decompositions of sulphates by organic matter in ocean water, are hardly known to take place. The phenomena at once become distinct, when land waters are allowed to mix, and the water from deep wells in the vicinity of the ocean has a more highly marked chemical action, than rain water. The decomposition of the sulphates proceeds under the presence of carbonic acid, and carbonates of the alkaline earths are products of the change.

1 Pine St., Boston, January, 1851.

Art. XXXI.—*On the Limit of Perpetual Snow in the Himalaya;* by Lieut. Strachey.*

"In this part of the Himalaya, it is not, on an average of years, till the beginning of December, that the snow line appears decidedly to descend for the winter. After the end of September, indeed, when the rains are quite over, light falls of snow are not of very uncommon occurrence on the higher mountains, even down to 12,000 feet; but their effects usually disappear very quickly, often in a few hours. The latter part of October, the whole of November, and the beginning of December, are here generally characterized by the beautiful serenity of the sky; and and it is at this season, on the southern edge of the belt, that the line of perpetual snow is seen to attain its greatest elevation.

The following are the results of trigonometrical measurements of the elevation of the inferior edge of snow on spurs of the Treslú and Nandádevi groups of peaks, made, before the winter snow had begun, in November, 1848.

Point. observed.	Height as observed on face exposed to the East.			Height on face exposed to West. Observed from Almorah.
	From Almorah, (height, 5586 ft.)	From Binsar, (height, 7969 ft.)	Mean.	
No.	Feet.	Feet.	Feet.	Feet.
1	16,599	16,767	16,683	15,872
2	16,969	17,005	16,987	——
3	17,186	17,185	17,185	14,878
4	15,293	15,361	15,327	——

The points 1, 2 and 3 are in ridges that run in the southwesterly direction. The dip of the strata being to the northeast, the

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* Jour. Asiatic Society of Bengal, New Series, No. xxviii, p. 287; cited from Humboldt's Views of Nature, Bohn's edition, p. 74.

faces exposed to view from the south are for the most part very abrupt, and snow never accumulates on them to any great extent. This in some measure will account for the height to which the snow is seen to have receded on the eastern exposures, that is, upwards of 17,000 feet. On the western exposures the ground is less steep, and the snow is said to have been observed at a considerable less elevation; but it was in very small quantities, and had probably fallen lately, so that I am inclined to think that its height, viz., about 15,000 feet, rather indicates the elevation below which the light autumnal falls of snow were incapable of lying, than that of the inferior edge of the perpetual snow. It is further to be understood, that below this level of 15,000 feet, the mountains were absolutely without snow, excepting those small isolated patches that are seen in ravines, or at the head of glaciers, which of course, do not affect such calculations as these. On the whole, therefore, I consider that the height of the snow-line on the more prominent points of the southern edge of the belt may be fairly reckoned at 16,000 feet at the very least.

The point No. 4 was selected as being in a much more retired position than the others. It is situated not far from the head of the Pindur river. It was quite free from snow at 15,300 feet, and I shall therefore consider 15,000 feet as the elevation of the snow-line in the re-entering angles of the chain.

I conclude, then, that 15,500 feet, the mean of the heights at the most and least prominent points, should be assigned as the mean elevation of the snow-line at the southern limit of the belt of perpetual snow in Kumaon; and I conceive that whatever error there may be in this estimate will be found to lie on the side of diminution rather than of exaggeration.

This result appears to accord well with what has been observed in the Bisseliir range. The account given by Dr. Gerard of his visit to the Shátúl Pass on this range, which he undertook expressly for the purpose of determining the height of the snow-line, contains the only definite information, as to the limit of perpetual snow at the southern edge of the belt, that is to be found in the whole of the published writings of the Gerards; and the following is a short abstract of his observations. Dr. Gerard reached the summit of the Shátúl Pass, the elevation of which is 15,500 feet, on the 9th of August, 1822, and remained there until the 15th of the same month. He found the southern slope of the range generally free from snow, and he states that it is sometimes left without any whatever. On the top of the pass itself there was no snow; but on the northern slope of the mountain it lay as far down as about 14,000 feet. On his arrival, rain was falling, and out of the four days of his stay on this pass, it either rained or snowed for the greater part of three. The fresh snow that fell during this time did not lie below

16,000 feet, and some of the more precipitous rocks remained clear even up to 17,000 feet.

The conclusion to which Dr. Gerard comes from these facts, is, that the snow-line on the southern face of the Bissehir range is at 15,000 feet above the sea. But I should myself be more inclined, from his account, to consider that 15,500 feet was nearer the truth; and in this view I am confirmed by verbal accounts of the state of the passes on this range, which I have obtained from persons of my acquaintance, who have crossed them somewhat later in the year. The difference, however, is after all trifling.

Such is the direct evidence that can be offered on the height of the snow-line at the southern limit of the belt of perpetual snow; some additional light, may, however, be thrown on the subject generally by my briefly explaining the state in which I have found the higher parts of the mountains at the different seasons during which I have visited them.

In the beginning of May, on the mountains to the east of the Rámganga river, near Námik. I found the ground on the summit of the ridge, called Champwá, not only perfectly free from snow at an elevation of 12,000 feet, but covered with flowers, in some places golden with Caltha and Ranunculus polypetalus, in others purple with Primulus. The snow had in fact already receded to upwards of 12,500 feet, behind which even a few little gentians proclaimed the advent of spring.

Towards the close of the same month, at the end of the Pindur, near the glacier from which that river rises, an open spot on which I could pitch my tent could not be found above 12,000 feet. But here the accumulation of snow, which was considerable in all ravines even below 11,000 feet, is manifestly the result of avalanches and drift. The surface of the glacier, clear ice as well as moraines, was quite free from snow up to nearly 13,000 feet; but the effect of the more retired position of the place in retarding the melting of the snow, was manifest from the less advanced state of the vegetation. During my stay at Pinduri the weather was very bad, and several inches of snow fell; but, excepting where it had fallen on the old snow, it all melted off again in a few hours, even without the assistance of the sun's direct rays. On the glacier, at 13,000 feet, it had all disappeared twelve hours after it fell.

On revisiting Pinduri about the middle of October, the change that had taken place was very striking. Now not a sign of snow was to be seen on any part of the road up to the very head of the glacier; a luxuriant vegetation had sprung up, but had already almost entirely perished, and its remains covered the ground as far as I went. From this elevation, about 13,000 feet, evident signs of vegetation could be seen to extend far up the less precipitous mountains. The place is not one at which the height

of the perpetual snow can be easily estimated, for on all sides are glaciers, and the vast accumulations of snow from which they are supplied, and these cannot always be readily distinguished from snow *in situ;* but as far as I could judge, those places which might be considered as offering a fair criterion were free from snow up to 15,000, or even 16,000 feet.

Towards the end of August I crossed the Barjikang Pass, between Rálam and Juhár, the elevation of which is about 15,300 feet. There was here no vestige of snow on the ascent to the pass from the southeast, and only a very small patch remained on the northwestern face. The view of the continuation of the ridge in a southerly direction was cut off by a prominent point, but no snow lay on that side within 500 feet of the pass, while to the north I estimated that there was no snow in considerable quantity within 1500 feet or more, that is, nearly up to 17,000 feet. The vegetation on the very summit of the pass was far from scanty, though it had already begun to break up into tufts, and had lost that character of continuity which it had maintained to within a height of 500 or 600 feet. Species of Potentilla, Sedum, Saxafraga, Corydalis, Aconitum, Delphinium, Thalictrum, Ranunculus, Saussurea, Gentiana, Pedicularis, Primula, Rheum, and Polygonum, all evidently flourishing in a congenial climate, showed that the limits of vegetation and region of perpetual snow were still far distant.

In addition to these facts it may not be out of place to mention that there are two mountains visible from Almorah, Rigoli-gúdri, in Garhwal between the Kailganga and Nandákni, and Chipula, in Kumaon, between Gori and Dauli (of Darma). both upwards of 13,000 feet in elevation, from the summits of which, the snow disappears long before the end of the summer months, and which do not usually again become covered for the winter till late in December."

These remarks are followed by an exposition of the errors into which Webb, Colebrooke, Hodgson, A. Gerard, and Jacquemont, have fallen. The heights assigned by these travellers "must all be rejected; nor can it be considered at all surprising that any amount of mistake, as to the height of the snow-line, should be made, so long as travellers cannot distinguish snow from glacier ice, or look for the boundary of perpetual snow at the beginning of the spring."

With regard to *the northern limit of the belt of perpetual snow*, Lieutenant Strachey's observations were made in September, 1848, on his way from Milam into Hundes, *viâ* Untadhúra, Kyungar-ghát, and Balch-dhúra, at the beginning of the month; and on his road back again, *viâ* Lakhur-ghát, at the end of the month.

"Of the three passes that we crossed on our way from Milam, all of them being about 17,000 feet in elevation, the first is Wata-dhára, and we saw no snow on any part of the way up to its top, which was reached in a very disagreeable drizzle of rain and snow. The final ascent to the pass from the south is about 1000 feet. The path leads up the side of a ravine, down which a small stream trickles, the ground having a generally even and rounded surface. Neither on any part of this nor on the summit of the pass itself, which is tolerably level, were there any remains of snow whatever. On the ridge to the right and left there were patches of snow a few hundred feet above; and on the northern face of the pass an accumulation remained that extended about 200 feet down, apparently the effect of the drift through the gap in which the pass lies. Below this again the ground was everywhere quite free from snow. On the ascent to Wata-dhára, at perhaps 17,000 feet, a few blades of grass were seen, but on the whole it may be said to be utterly devoid of vegetation. On the north side of the pass, 300 or 400 feet below the summit, a cruciferous plant was the first met with.

The Kyungar pass, which is four or six miles north of Wata-dhára, was found equally free from snow on its southern face and summit, which latter is particularly open and level. The mountains on either side were also free from snow to some height; but on the north a large bed lay a little way down the slope, and extended to about 500 feet from the top. On this pass, a boragineous plant in flower was found above 17,000 feet; a species of *Urtica* was also got about the same altitude, and we afterwards saw it again nearly as high up on the Lákhur pass.

In our ascent to the Balch pass, no snow was observed on any of the southern spires of the range, and only one or two very small patches could be seen from the summit on the north side. The average height of the top of this range can hardly be more than 500 feet greater than that of the pass; and as a whole it certainly does not enter the region of perpetual snow. As viewed from the plains of Handes, it cannot be said to appear snowy, a few only of the peaks being tipped.

We returned to Milam *viâ* Chirchun. The whole of the ascent to the Lákhur pass was perfectly free from snow to the very top, *i. e*, 18,300 feet and some of the neighboring mountains were bare still higher. The next ridge on this route is Jainti-dhára, which is passed at an elevation of 18,500 feet, but still without crossing the least portion of snow. The line of perpetual snow is however evidently near; for though the Jainti ridge was quite free, and some of the peaks near us were clear probably to upwards of 19,000 feet, yet in more sheltered situations unbroken snow could be seen considerably below us; and on the whole I think that 18,500 feet must be near the average height of the snow-line at this place.

A brief recapitulation of the principal results of Lieutenant Strachey's inquiries shows that "the snow-line or the southern edge of the belt of perpetual snow in this portion of the Himalaya is at an elevation of 15,000 feet, while on the northern edge it reaches 18,500 feet; and that on the mountains to the north of the Sutlej, or still further, it recedes even beyond 19,000 feet. The greater elevation which the snow-line attains on the northern edge of the belt of perpetual snow is a phenomenon not confined to the Thibetan declivity alone, but extending far into the interior of the chain; and it appears to be caused by the quantity of snow that falls on the northern portion of the mountains being much less than that which falls farther to the south along the line where the peaks, covered with perpetual snow, first rise above the less elevated ranges of the Himalayas."

ART. XXXII.—*Analyses of the Ashes of certain Commercial Teas;* communicated by Prof. E. N. HORSFORD, of Harvard University.

1. *Souchong Tea; by Edward A. Spooner, of the Cambridge Laboratory.*

1*st Sample*:—per-centage of ash yielded by the tea, 5·48

A qualitative examination conducted according to the method of Will and Fresenius gave for the constituents of the ash, potassa, soda, lime, magnesia, peroxyd of iron, phosphoric, sulphuric, hydrochloric, silicic and carbonic acids, charcoal and sand.

A quantitive analysis gave the following per-centage of the several constituents.

	Results of analysis.	Per-centage, carbonic acid, charcoal and sand excluded.
Potassa,	3·31	3·70
Soda,	22·78	25·46
Lime,	10·40	11·63
Magnesia,	8·58	9·59
Peroxyd of iron,	7·53	8·42
Phosphoric acid,	11·29	12·62
Sulphuric acid,	9·07	10·14
Chlorid of sodium,	2·15	2·40
Silica,	14·35	16·04
Carbonic acid,	2·85	——
Charcoal and sand,	5·38	——
	97·69	100·00

2d Sample:—per-centage of ash, 6·106.
The analysis gave in 100 parts:

	Results of analysis.	Per-centage, unessential ingredients excluded.
Potassa,	40·51	44·96
Soda,	1·53	1·70
Lime,	7·90	8·77
Magnesia,	7·58	8·41
Peroxyd of iron,	6·13	6·80
Phosphoric acid,	10·33	11·46
Sulphuric acid,	6·27	6·96
Chlorid of sodium,	1·94	2·15
Silica,	7·92	8·79
Carbonic acid,	2·26	——
Charcoal and sand,	7·39	——
	99·76	100·00

2. *Oolong Tea; by Robert C. Tevis, A.B., of the Cambridge Laboratory.*

Per-centage of ash, 5·14
The analysis gave in 100 parts:—

	Results of analysis.	Per-centage, charcoal, sand and carbonic acid excluded.
Potassa,	11·57	12·38
Soda,	37·40	40·00
Lime,	7·19	7·68
Magnesia,	5·77	6·17
Peroxyd of iron,	6·71	7·18
Chlorid of sodium,	2·10	2·25
Phosphoric acid,	7·72	8·26
Sulphuric acid,	7·73	8·27
Silicic acid,	7·30	7·81
Carbonic acid,	2·30	——
Charcoal and sand,	3·72	——
	99·51	100·00

3. *Young Hyson Tea; by J. M. Hague, of the Cambridge Laboratory.*

Per-centage of ash, 5·94.
The analysis gave in 100 parts:

	Results of analysis.	Per-centage, carbonic acid, charcoal and sand excluded.
Potassa,	30·84	33·95
Soda,	8·42	9·26
Lime,	7·43	8·17
Magnesia,	6·17	6·79
Peroxyd of iron,	4·32	4·75

	Results of analysis.	Per-centage, carbonic acid, charcoal and sand excluded.
Chlorid of sodium,	4·24	4·66
Phosphoric acid, .	15·12	16·64
Sulphuric acid, .	4·40	4·89
Silicic acid, . .	9·90	10·89
Carbonic acid, .	3·83	——
Charcoal and sand,	5·98	——
	100·65	100·00

4. *Ninyong Tea; by Charles S. Homer, Jr., of the Cambridge Laboratory.*

Per-centage of ash, 4·73.

The analysis afforded in 100 parts—

	Results of analysis.	Per-centage, carbonic acid, charcoal and sand excluded.
Potassa, . .	24·75	28·38
Soda, . . .	11·24	12·88
Lime, . . .	7·32	8·39
Peroxyd of iron, .	16·84	19·31
Chlorid of sodium,	2·84	3·25
Phosphoric acid, .	15·22	17·44
Sulphuric acid, .	4·16	4·76
Silica, . .	4·86	5·59
Carbonic acid .	4·01	——
Charcoal and sand,	9·09	——
	100·33	100·00

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Latent heat of Ice.*—Person has determined the latent heat of fusion of ice at 0° C. and at lower temperatures, and has ascertained that in order to obtain the *total* quantity of heat which is absorbed when ice becomes liquid, it is necessary to set out from a temperature somewhat below 0°. The experiments were made by means of a calorimeter founded on the method of mixtures. The loss of heat by radiation was compensated by placing the calorimeter in a space the temperature of which could be made to follow that of the calorimeter itself, and the method was verified by determinations of the specific heat of water at different temperatures which agree well with those of Regnault. The author first determined the specific heat of ice between −21° C. and −2° C., employing in the calorimeter a solution of salt the specific heat of which had been previously determined. The specific heat of ice between the limits above mentioned was found to be 0·48. In determining the latent heat the ice was formed into cylinders in the axes

of which were placed thermometers showing $\frac{1}{100}$th degree; the time of fusion in the calorimeter was on the average about 12 minutes. It was found that the latent heat of fusion of ice was very nearly constant setting out from a temperature of $-2°$, and was then represented by 79·97. From this it may be inferred that ice approaches very near its point of fusion without sensibly changing its consistence, the slight softening which precedes the fusion being comprised within an interval of 2 degrees: the passage of ice from a solid to a liquid state though sufficiently well defined is still effected by degrees and not abruptly. It will be remembered that De la Provostaye and Dessains on the one hand, and Regnault on the other, had found for the latent heat of ice the number 79; the experiments of Regnault had however clearly shown that this number was not constant but increased as the initial temperature of the ice diminished at least as far as $-0·61$, for which the corresponding latent heat was 79·71.—*Ann. de Chimie et de Physique, Sept.*, 1850.

2. *Liquefaction of Gases.*—Berthelot has applied the expansive force of heated liquids to the liquefaction of gases upon a small scale. A thick glass tube having a small bore is to be sealed at one end and then filled with pure and dry mercury free from air; the open end of the tube is then to be drawn out to a capillary orifice, without diminishing the ratio between the thickness and the interior diameter of the tube. The column of mercury is then to be heated in a water bath and the point of the tube kept in an atmosphere of the gas which it is wished to condense; when the tube is allowed to cool a portion of the gas equal to that of the mercury which has flowed out enters; the tube is now to be withdrawn and the point sealed; then the column of mercury is to be again heated in the water bath when the gas will condense into a drop easily visible with a lens and in many cases with the naked eye. The author suggests the employment of the gas or solar microscope to exhibit the phenomena at once to a large audience. Ammonia, carbonic acid and chlorine were easily liquefied in this manner, the tube for chlorine having been filled with pure and concentrated sulphuric acid.—*Ann. de Chimie et de Physique, October*, 1850.

3. *Evolution of Light at the Negative Pole of the Galvanic Series.*—Moigno has presented to the Academy of Sciences in Paris a memoir on the experiments of Neeff in Frankfort on the development of light and heat in the galvanic circuit. The author witnessed in person the experiments of the German physicist and considers it proved, 1st, that *Light* always appears at the *negative* pole, and that this primitive light is independent of combustion, 2d, that the source of the *Heat* is properly the *positive* pole, and that this heat is originally *dark* heat, 3d, that Light and Heat do not unite in the instant of evolution but only after the intensity of each has reached a certain point; from this union ensue the phenomena of flame and combustion. The facts stated were further verified by means of De la Rive's apparatus in which the poles of the battery were made to terminate in two iron cylinders terminating in acute cones; it was easily found by the finger alone that the iron connected with the negative pole was still cold, when the other had already become very hot. The experiments were subsequently repeated in Paris by means of an apparatus contrived by Duboscq to

moderate and regulate the galvanic light; the author interrupted the circuit repeatedly by separating the carbon-poles from each other and then causing them to approach again; at every new contact the originally white light showed itself upon the carbon of the negative pole, but *soon after* the completion of the circuit the combustion began at the positive pole, the carbon here became hollowed out and emitted a far more brilliant light than that of the negative pole. The regulator of M. Duboscq appeared to leave nothing to be desired, the variations of the electric light becoming wholly insensible.—*Comptes Rend.*, xxx, 359; *and Pogg. Ann.*, 1850, *No.* 10, 318.

4. *Compounds of Phosphorus and Iodine.*—Corenwinder has studied in detail the definite compounds of iodine and phosphorus obtained by dissolving the two substances together in bisulphid of carbon and to which we have already alluded.* The author infers from these researches that there exist but two compounds of phosphorus and iodine, —a biniodid and a teriodid; these may be obtained in the manner already described.* The biniodid of phosphorus has no analogue in the oxygen series of this substance; as already stated, it crystallizes in large orange red prisms which fuse at 110°; the fused liquid is of a beautiful clear red; it is decomposed by water yielding iodohydric and phosphoric acids together with a yellowish flocky matter which was not examined; the crystals must be preserved in sealed tubes. The teriodid, obtained by dissolving together 1 eq. of phosphorus with 3 of iodine, crystallizes in confused hexagonal plates which have a red color; heated in a water bath to expel the bisulphide they fuse and the liquid on cooling gives a garnet-colored mass. The bisulphid can however only be perfectly expelled by submiting the iodid to a temperature of from 50° to 60° and passing over it a current of dry air, it then crystallizes by fusion in prisms of very large dimensions and is perfectly pure; water decomposes it readily into phosphorous and iodohydric acids. The author has further remarked that when a current of dry chlorine is passed into bisulphid of carbon charged with phosphorus the gas is wholly absorbed, and when the liquid is supersaturated with chlorine and allowed to stand in a cool place, perchlorid of phosphorus crystallizes in well defined white crystals.—*Ann. de Chimie et de Physique, October*, 1850.

5. *On the employment of Hydrogen in Mineral Analyses.*—Rivot has employed the reducing action of hydrogen for the separation of iron from associated irreducible oxyds. To separate iron from alumina the author precipitates the two oxyds together in the usual manner by ammonia; the precipitate is dried and ignited, and a weighed portion in a small weighed porcelain vessel is placed in a tube disposed horizontally in a furnace; the air is expelled by a slow current of dry hydrogen, and the tube is gradually heated to redness and maintained at this temperature as long as water is formed; the tube is then allowed to cool while the gas still passes through it; when cold the porcelain vessel is withdrawn and weighed; the loss of weight gives the oxygen in the peroxyd. As a control the iron may be dissolved out from the mixture by means of dilute nitric acid in the cold; pure ordinary acid diluted with

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* This volume, p. 108.

30 times its weight of water takes up in the course of 24 hours the whole of the iron without a trace of alumina. The result obtained in this manner by operating upon artificially prepared mixtures of the two oxyds was satisfactory, though it must be remarked that the author employed the old equivalent of iron 339 in his calculations. The same process was also found to give accurate results in separating iron from zirconia, glucina, and oxyd of chromium, and in the analysis of ores of tin. [*Note.*—Should the accuracy of the methods here indicated be verified by other chemists, it might be advantageous to substitute a porcelain crucible with a bored cover and porcelain tube as recommended by Rosé for the far less convenient arrangement of Rivot.]—*Ann. de Chimie, October*, 1850.

6. *Capronic and Œnanthic Acids.*—Brazier and Gossleth have contributed many new and interesting facts to the chemical history of these two acids. Capronic acid was prepared from cyanid of amyl $C_{10}H_{11}Cy$, by distillation with an alcoholic solution of caustic potash; the capronate of potash thus obtained was treated with sulphuric acid and the capronic acid separated as an oily liquid which was purified by distillation; the boiling point of the pure acid was found to be 198° C.; toward the end of the distillation, however, the boiling point rose to 211° and there passed over a liquid which after rectification had a constant boiling point at 211° and proved to be capronate of amyl, $C_{10}H_{11}O+C_{12}H_{11}O_3$. By the dry distillation of capronate of baryta, the authors obtained among other liquid products caprone, $C_{11}H_{11}O$, as a colorless liquid, insoluble in water, soluble in alcohol and ether and boiling at 165° C.; gaseous products, probably hydrocarbons of the series CnHn, were evolved at the same time. By the action of nitric acid upon another body of the acetone series, butyrone C_7H_7O, Chancel obtained a new acid, nitropropionic acid $C_6H_4(NO_4)O_3+HO$; Brazier and Gossleth have studied the action of nitric acid upon caprone and have rendered the formation of a similar acid nitrovaleric acid, $C_{10}H_8(NO_4)O_3+HO$, highly probable. By the action of the galvanic current upon a solution of capronate of potash the authors obtained a new hydrocarbon identical or isomeric with the radical amyl, $C_{10}H_{11}$, and which had already been obtained by Frankland by the action of zinc upon iodid of amyl; they point out the remarkable fact that the action of zinc upon the iodid of an alcohol-radical $CnHn+1I$, and that of the galvanic current upon an acid of the formula $Cn+2Hn+2O_4$, gives rise to one and the same product. By the electrolysis of œnanthate of potash, a homologous compound was obtained as an oily liquid boiling at 202°, having an agreeable aromatic odor, insoluble in water but soluble in alcohol and ether. Its constitution is represented by $C_{12}H_{13}$, and the authors term it provisionally Caproyl; by repeated distillation with a mixture of nitric and sulphuric acids caproyl yields capronic acid. Bromine has little or no action upon caproyl even in the sunlight; chlorine acts however powerfully converting the liquid into a tough mass with evolution of chlorohydric acid.—*Ann. der Chemie u. Pharmacie*, lxxv, 249.

7. *Amylo-sulphuric Acid.*—Kekulé has studied amylo-sulphuric acid and its compounds, $C_{10}H_{11}O, SO_3+SO_3, RO$; of the results obtained, however, the only one which deserves special notice is

that relating to the action of heat upon amylo-sulphate of lime. When amylo-sulphate of lime is submitted to dry distillation, carbonic and sulphurous acids are given off and two liquids are obtained differing in volatility; the more volatile boiled at 42° C., was colorless and without taste, highly fluid, lighter than water, readily inflammable and exhibiting a faint odor of garlic which could not be removed even by repeated distillation; its formula is $C_{10}H_{10}$, and it is consequently identical with amylene obtained by Balard by the distillation of amylic alcohol with chlorid of zinc. The substance analyzed was however not absolutely pure, but contained a small quantity of some sulphur-compound. The less volatile liquid obtained did not possess a constant boiling point—the portion boiling between 165°–175° gave pretty nearly the formula of amylic ether, $C_{10}H_{11}O$, with which however its boiling point does not correspond. From the results of this investigation the author infers that in the dry distillation of an amylo-sulphate one portion of the oxyd of amyl passes over as such, one portion resolves itself into amylene and water, a third part is completely decomposed into water, carbonic acid, and carbon, while a fourth forms with the sulphur of the sulphuric acid a sulphur compound in quantity too small to admit of investigation; half of the sulphuric acid remains in combination with the base, the other half passes off as sulphurous acid, sulphur, and some organic matter containing sulphur. —*Ann. der Chemie u. Pharmacie*, lxxv, 275, *September*, 1850.

8. *New allotropic modification of Phosphorus.*—Schrötter has demonstrated that the change of color produced in phosphorus by the action of light is independent of the presence of oxygen; that it occurs even when the phosphorus is surrounded with an atmosphere of pure and dry hydrogen, carbonic acid, or nitrogen, and that it is due simply to the passage of the element into an allotropic state or form. Precisely the same change was produced by exposing phosphorus for some time to a temperature of 226° C.; the mass assumed a fine red color and became gradually less fluid, darker, and finally perfectly opaque. The precise temperature at which the change takes place could not be determined inasmuch as a less degree of heat produces in a longer, the same effect which a higher temperature produces in a shorter, time. The joint action of heat and light was also found more efficacious than either of these agents separately. The author compares the two allotropic modifications of phosphorus with those of carbon; the diamond when strongly heated passing into an amorphous state and becoming black and opake. Amorphous phosphorus is most readily prepared by exposing common phosphorus to the action of heat or light, and then dissolving out the unchanged substance by means of bisulphid of carbon and filtering, taking care to keep the filter full of liquid till a portion of the filtrate evaporated on a strip of platinum no longer leaves a trace of phosphorus. The substance on the filter is to be boiled with a solution of caustic potash of density 1·30 and washed, first with pure water, then with very dilute nitric acid, and finally again with pure water. The new modification of phosphorus is an amorphous powder, without lustre, and of a color which varies from scarlet-red to dark carmine-red but which may become dark brown or brownish black: when washed it becomes violet, recovering its original color when cold. Its density at 10° C. is 1·964. Amorphous

phosphorus is insoluble in bisulphid of carbon, alcohol, ether, naphtha and perchlorid of phosphorus; boiling oil of turpentine takes up a small quantity of it; in the air it remains wholly unchanged. It is not luminous in the dark at ordinary temperatures but becomes slightly so near the temperature at which it ignites. Chlorine acts upon amorphous phosphorus at the ordinary temperatures but without evolution of light, yielding terchlorid or pentachlorid according to the quantity of chlorine; bromine unites with it with a vivid ignition; iodine has no action at common temperatures, but when the two substances are heated together in an atmosphere of any indifferent gas they unite quietly forming an orange yellow iodid and a less volatile, scarlet, crystalline compound, probably a teriodid. A solution of caustic potash dissolves amorphous phosphorus on boiling with evolution of phosphuretted hydrogen not spontaneously inflammable: the more concentrated the solution the more easy is the decomposition, the finely divided amorphous phosphorus assuming a dark chocolate brown color. Schrötter considers it probable that the black phosphorus of Thenard is the same allotropic modification with that which he has described. Nitric acid readily oxydizes amorphous phosphorus, the increased surface of the latter forming many points of attack. Finally, neither copper nor other metallic substances are precipitated from their solutions by amorphous phosphorus. The author recommends this substance in an economical point of view for the preparation of friction-matches and percussion caps, as it possesses over ordinary phosphorus the great advantages that it is neither affected by the moisture of the atmosphere nor injurious to the health of the workmen. In a second paper the author fully confirms the results which he had previously obtained, and adds among other interesting facts the remarkable one that common phosphorus is capable of decomposing water at a temperature between 250° C. and 260° C. It should have been stated above that the amorphous modification of phosphorus is reconverted into common or crystallizable phosphorus when heated above its boiling point in an atmosphere of hydrogen or nitrogen.—*Pogg. Ann.*, 1850, *No.* 10.

9. *Theory of Organic Radicals.*—Kolbe has published an elaborate and most interesting memoir on the chemical constitution and nature of the organic radicals. The paper however is not one which readily admits of condensation, and we must therefore refer to the original.—*Ann. der Chemie u. Pharmacie*, lxxvi, 1.

10. *On a compound of Chlorine, Phosphorus and Nitrogen.*—Gladstone has studied a compound of chlorine, nitrogen and phosphorus, originally discovered by Wöhler and Liebig, but not investigated by them. The chloro-phosphuret of nitrogen is always formed when pentachlorid of phosphorus is saturated with ammonia, and its formation is independent of moisture in the ammonia employed; no traces however are formed when terchlorid of phosphorus is saturated in a similar manner. When 1 part of pentachlorid and 2 parts of dry sal-ammoniac are heated together in a flask connected by means of bored corks and tubes with two or more receivers, the chloro-phosphuret sublimes, in the first receiver which is kept cool a colorless liquid appears containing a small quantity of a white powder, while chlorohydric acid gas passes off and is condensed in the second receiver in

which water is placed. The chloro-phosphuret of nitrogen is purified by crystallization from ether; at ordinary temperatures it is a solid crystalline substance which at 110° C. fuses to a clear liquid and begins to boil at 240°. The crystals obtained by sublimation are rhombic prisms, the acute angle of which measures 48°–49° and is sometimes replaced by a plane: in crystals obtained from alcoholic or etherial solutions the replacement of the acute angle is common. The density of the crystallized compound is somewhat greater than that of water, that of the fused substance somewhat less; on heating, dense vapors are given off, which leave a peculiar and rather agreeable smell. It is perfectly insoluble in water, soluble on the contrary in alcohol, chloroform, benzole, oil of terpentine, and particularly in ether. Powerful oxydizing agents decompose the chloro-phosphuret of nitrogen with formation of phosphoric acid; alcoholic solutions of potash, soda and ammonia also decompose it, forming chlorids and other salts of the bases used. The empirical formula of the chloro-phosphuret is $N_2P_3Cl_5$, which corresponds precisely with the results of Wöhler and Liebig. By the action of an alcoholic solution of caustic potash a new salt was obtained which gave with persalts of iron a white flocky precipitate resembling common phosphate of iron, but soluble in dilute acids and perfectly soluble in ammonia; its formula was found to be Fe_2O_3, P_2NO_5+4HO. Other salts of the same acid were formed, of which it will be sufficient to indicate the formulas

$$3CuO, P_2NO_5+5HO$$
$$3AgO, P_2NO_5+5HO$$
$$3BaO, P_2NO_5+2HO$$
$$3KO, \ P_2NO_5+5HO$$

The author proposes to return to the subject and to describe other products of the decomposition of the chloro-phosphuret of nitrogen: the new salts are termed nitro-phosphates; the acid was also isolated as a semi-fluid uncrystallized mass, and when super-saturated with ammonia gave with sulphate of peroxyd of iron a clear red solution which was considered the most characteristic and simple test.—*Ann. der Chemie u. Pharmacie*, lxxvi, 74.

11. *Quantitative separation of Potash and Soda.*—Rose has found that the fluo-silicates of potassium and sodium are wholly insoluble in a liquid containing alcohol. When fluo-silicic acid in excess is poured into a solution of a potash or soda salt and a volume of strong alcohol equal to that of the whole liquid is added, the whole of the potash or soda present is precipitated in the form of a fluo-silicate which is to be washed with strong alcohol diluted with an equal volume of water. Baryta may be separated from its solutions in a similar manner; a very small proportion of alcohol however suffices for its complete precipitation.—*Monats-bericht der Akademie der Wissenschaften zu Berlin, July*, 1850.

12. *Constitution of Tourmaline.*—Rammelsberg has communicated to the Royal Academy of Berlin the results of the analyses of thirty varieties of this remarkable mineral. Admitting the isomorphism of boric and silicic acids, the author arrives at the conclusion that as in the cases of feldspar and mica, the ratio between the quantities of oxygen in the protoxyds and the quantities in the sesquioxyds and the

two acids is different for different tourmalines. The ratio in question was found to be

in six varieties	= 1 : 3 : 5	spec. grav. mean			3·05
in eight "	= 1 : 4 : 6	"	"	"	3·10
in six "	= 1 : 6 : 8	"	"	"	3·20
in six "	= 1 : 9 : 12	"	"	"	3·08
in four "	= 1 : 12 : 15	"	"	"	3·04

The author divides the tourmalines into two classes :—A. Dark (brown or black) tourmalines; these contain no lithia, and the first member of their formulas is always a bisilicate ($\dot{R}^3\ddot{S}i^2$.) B. Light (blue, green and red) tourmalines; these contain lithia, and the first member of their formulas is always a trisilicate ($\dot{R}\ddot{S}i$); this class includes the transparent varieties. Class A, is further subdivided into 3 groups, for which Rammelsberg proposes the following names.

(1.) *Magnesia tourmalines.*—Oxygen ratio 1 : 3 : 5. Sp. Gr. 3·05. Formula $\dot{R}^3\ddot{S}i^2+3\dot{R}\ddot{S}i$. These contain the maximum of magnesia but very little iron. In this group belong the yellow and brown varieties from Gouverneur, N. Y., Orford, N. H., Monroe, Ct., Windisckappel in Carinthia, Eibenstock in the Harz, and the Zillerthal.

(2.) *Magnesia-iron tourmalines.*—Oxygen ratio, 1 : 4 : 6. Sp. Gr. 3·1. Formula $\dot{R}^3\ddot{S}i^2+4\dot{R}\ddot{S}i$. These contain on an average from 6–9 per cent. magnesia, and 3–14 per cent. oxyds of iron. This group embraces the apparently black varieties from Pennsylvania, Haddam, Unity, Ramfossen in Norway, Godhale in Greenland, St. Gotthard.

(3.) *Iron tourmalines.*—Oxygen ratio, 1 : 6 : 8. Sp. Gr. 3·2. Formula $\dot{R}^3\ddot{S}i^2+6\dot{R}\ddot{S}i$. These contain the maximum of the oxyds of iron (12–18 per cent.) but very little magnesia. In this group we find the black tourmalines of Bovey-Tracey in England, Andreasberg in the Harz, and from Saar in Moravia, Krummau in Bohemia and Langbielau in Silesia.

Class B comprises two groups.

(4.) *Iron-manganese tourmalines.*—Oxygen ratio 1 : 9 : 12. Formula $\dot{R}\ddot{S}i+3\dot{R}\ddot{S}i$. Sp. Gr. 3·08. These are characterized by containing both metals. They comprise the green, blue and violet varieties—the green from Elba, Paris in Maine, Brazil, and Chesterfield, Mass., the dark brownish-violet from Elba, and the blue from Sarapulsk in the Ural.

(5.) *Manganese tourmalines.*—Oxygen ratio 1 : 12 : 15. Sp. Gr. 3·04. Formula $\dot{R}\ddot{S}i+4\dot{R}\ddot{S}i$. These are red or nearly colorless varieties free from iron, as those from Elba, Paris in Maine, Schaitansk in the Ural and Rozena in Moravia.

In both classes tourmalines are found which are perfectly opake when cut parallel to the axis and examined in polarized light.

The author has further examined the micas and their relations to the tourmalines. The so-called potash-micas which have commonly a white color, were found to be divisible into three groups in which the oxygen ratios of the alkalies, alumina and acid are 1 : 6 : 9, 1 : 9 : 12, 1 : 12 : 15;* the second and third of these groups are identical with the fourth and fifth of the tourmalines.—*Monatsbericht der Akademie der Wissenschaften zu Berlin, July*, 1850, *and Pogg. Ann.*, 1850, No. 8 and 9.

W. G.

* The ratio 1 : 12 : 15 is incorrectly deduced by Rammelsberg, by making $\frac{3}{4}$: 9 : 12, the true ratio, equal to 1 : 12 : 15, whereas it should be 1 : 12 : 16, as shown by Mr. Dana in his Mineralogy, p. 687, and in this Journal, vol. x, p. 114.

13. *Manganese in the urine*; by Prof. E. N. HORSFORD.—By evaporating fifty cubic centimeters of normal human urine over a water-bath, in platinum, to dryness, and igniting the residue, I have observed, in three of fourteen trials, on as many different occasions, unequivocal traces of *manganese*. The presence of this body in the ashes of several varieties of tea, coffee, potato, and squash, which has recently been demonstrated in the Cambridge Laboratory, leaves no doubt as to the source from which the manganese may have been derived.

The above observations relieve the experiments of Millon,* which led him to believe in the existence of manganese in the blood, from the imputation of Melsens,† that the metal may have been supplied from the vessels or reagents employed in the examination.

II. MINERALOGY AND GEOLOGY.

1. *Liebigite*; by J. LAWRENCE SMITH.—This mineral, which I discovered about two years ago on a specimen of pitchblende from Adrianople, Turkey, along with another new mineral that I called Medjidite, exists in one of the European localities of pitchblende, namely, Johanngorgenstadt. The first specimen I found was in the cabinet of the School of Mines at Paris; there is another in the Yale College cabinet, and a third in Prof. Shepard's collection. It exists as a thin, yellowish, apple-green coating, semitransparent, easily detached from the surface of the pitchblende, and is instantly recognized by heating it on a piece of platinum foil, when it loses water, blackens at a red heat, and on cooling becomes orange red. It also effervesces violently with the strong acids, furnishing a test of uranium and lime. A European locality being now known, there will not be much difficulty in obtaining specimens. I also think that I have found the Medjidite from specimens of the same locality, but not having such a marked test for this mineral, I could not decide on the little I obtained from a specimen which is in the cabinet of the Garden of Plants.

2. *On the Geology of Spain*; by DON JOAQUIN EZQUERRA DEL BAYO, (Quart. Journ. of the Geological Society, November, 1850. p. 406.)—In order to give a general idea of the geological constitution of our country, it may be considered as consisting of three principal divisions, viz. the Crystalline or Gneissoid formations; the Transition formations; and the Secondary. The first predominate almost exclusively in the western portions (not including Portugal), in the whole of the ancient kingdom of Galicia, and extends through Astorga, Zamora, Salamanca, Placencia, Cáceres, Mérida, Lleréna, Aracéna, and Rio Tinto, to the north of Seville and to the neighborhood of Italica, the birth-place of the Emperor Trajan, now called Sancti Ponce. It must however be observed, that as yet, for want of detailed observations, we have no definite lines to mark the limits of the three formations above mentioned. We can say only that the gneiss rocks occupy about a fifth of the surface of the soil, extending longitudinally from north to south, but throwing out, as it were, ramifications toward the east.

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* Journal de Ph. et de Chim., 3 Sér., t. xiii, p. 86–88.
† Ann. de Chem. et de Phys., 3 Sér., t. xxiii, p. 388–392.

These gneiss rocks are probably secondary or primary formations, altered by the plutonic rocks which have penetrated them. These are generally ordinary granite, more or less coarse-grained, and sometimes traversed by veins or dykes of porphyritic granite. Only at the northern extremity, viz. between Aracéna and Lleréna, in the villages of Zufre and Santa Olalla, is a great syenitic outburst visible.

The most important of these granitic ramifications to the east, is that which passes by the Sierra de Gridos, Sierra d'Avila, and the Guadarrama, to Somo Sierra, in a direction from southwest to northeast. The great granitic outburst of Truxillo and of the mountains of Toledo does not extend so far to the east. A third, which is not so well marked as the other two, *i. e.* does not appear on the surface with the same continuity, is that which has probably given its present form to the Sierra Morena. It terminates at Linares, in the province of Jaen.

The gneiss rocks in Spain do not generally abound in metalliferous deposits. There are some however of considerable importance. All the copper deposits of the district of Rio Tinto occur in talcose schist, in the vicinity of the granite. The famous mines of Guadalcanal and of Cazalla (now exhausted) are opened in chloritic schist, not far from the syenitic outburst. The rich argentiferous veins lately discovered at Hiendelencina, in the province of Guadalaxara, traverse the real gneiss, and are also not very distant from the granite of Somo Sierra.

The plutonic rocks themselves are still less rich in useful metals compared with their great development. The most important deposit in a rock of this character is the great system of lead and copper veins in the district of Linares, both for the abundance and excellent quality of the minerals. The granitic rocks in the neighborhood of Monterey in Galicia contain a small quantity of tin, as well as those of Carbajosa and Carbajoles, near Zamora, on the frontier of Portugal. To this last formation must also be referred the carbonate of lead and the antimonial-ochre of Losacio, in gneiss entirely surrounded by granite. These rich and abundant minerals of Losacio have not yet proved profitable to the speculator, for want of an economical method of carrying on their operations. The auriferous sands of Galicia, which the Romans worked on so large a scale, and from which the inhabitants still obtain a considerable revenue by washing, and those of the Guadiana and of the Tagus, which are slightly worked in Estremadura, are all derived from the disintegration of the granitic rocks. The auriferous sands of the Darro and the Gerril, sung by the Arab and Andalusian poets, are not worth mentioning; they are very poor, and are not derived from the same source.

The oldest sedimentary or transition rocks, in their different stages, the present forms of which are owing to volcanic eruptions, are in Spain most rich in mineral wealth. The whole range of the Cordilleras of the province of Granada down to the sea, and almost the whole coast from near Gibraltar to beyond Carthagena, belong to this period; consisting of slates, argillaceous schists, and mountain limestone, or rather metalliferous limestone. Fossils are very scarce. The Silurian formation is well characterized in the Sierra Morena, from Santa Cruz de Mudela to Almaden, with its remarkable deposit of Cin-

nabar. It also occurs in the mountain-chain of Asturia, which contains coal of good quality.

The secondary formations, which are shut in between the older rocks and the sea, occupy a great area in the centre of Spain, extending to the north and to the eastern coast. The greater part of these secondary rocks belong to oolitic and cretaceous periods; all the members of the series are fully developed except the Muschelkalk.

The Devonian formation is very limited. Some traces of it occur in the centre of the Asturias, and a still larger development occurs in the northern part of the province of Léon, which extends as far as Galicia, following a line parallel with the mountain-chain of Cantabria. In both these localities the Devonian rocks abound with coal of an excellent quality. That of the Austurias, which was already known at the close of the last century, not only in the Devonian, but in other formations, will hardly come into competition with other coals, unless the company by which it is worked agree to lay out larger sums in working it. That of Léon is more easily obtained, and although it has been known only for a few years, it is already a source of considerable industry in Castille. It is taken to Madrid for the cast-iron foundries and other works, as gas-lighting, &c.

On the Silurian rocks of the Sierra Morena, which we have alluded to, proceeding toward the south, reposes the great coal formation of Espiel and Belsuez, which may be called the basin of the Guadiato, the river by which it is traversed. This formation may be traced for a distance of fourteen leagues from west to east, and extends to within three leagues of Cordova. At Villanueva del Rio, on the right bank of the Guadalquivir, eleven leagues northeast from Seville, is a small basin of coal, extending over nearly a square league of ground. This coal is not of very good quality, being friable and dusty; nevertheless, owing to its situation so near the river and Seville, many thousand quintals are annually extracted. This is the whole extent of the true Carboniferous system in Spain.

The New Red Sandstone formation contains an extensive development of the Zechstein limestone, which forms almost the sole constituent of the Sierras of Alcazar, of the Sagra, of Cazorla, and of Castril, in the provinces of Jaen, Albacete, and Murcia. The *marnes irisées* have not yet been clearly made out; this is a great deficiency in our geology. There may be perhaps some traces in Moncayo, near Calcena in Aragon, and also in the mountains of Léon, and possibly in the province of Guadalaxara, towards Tamajon, with slight indications of coal. It is said that in La Mancha (now the province of Ciudad Real) the zechstein occurs with its *marnes irisées* and *todt-liegendes*, resting against the northern slope of the Sierra Morena; I have not seen it. At San Juan d'Alcaraz, in the Sierra of the same name, near the village of Riopar, the marls and dolomites are well characterized, and contain a rich deposit of calamine, the working of which is every day becoming more productive. I think I have discovered the Kupferschiefer of the Germans near Archidona, between Sierra de Lucena and Sierra d'Antequera.

The Jurassic or Oolitic formation constituted, to all appearances, the bottom of the sea during the cretaceous period, inasmuch as it

everywhere rises above the surface when the cretaceous formation is interrupted. There is, however, a considerable extent of it exposed, as *e. g.* the whole mountain range, which, commencing near Burgos, continues towards the east through the province of Soria, as far as Moncayo, and thence into Aragon, passing near Arina, as far as Feruel. This ridge of oolitic rock is slightly interrupted by the chalk and tertiary beds, but it again appears in the kingdom of Valencia as far as the town of the same name; so that, in fact, the oolitic formation can be traced from Valencia to Burgos for a distance of 180 Spanish leagues (900 kil.) forming an obtuse angle at the culminating-point of Moncayo. I have observed the same beds at Siguenza and Torremocha, in the province of Guadalaxara, in Andalusia near Cabra, in the province of Cordova, and in the Basque provinces, as is laid down in the Geological Map of France. It probably exists in other localities not yet accurately investigated.

The oolitic formations of Spain have in my opinion some remarkable features. They abound in metalliferous deposits of all kinds, generally scattered in small isolated masses, and seldom in veins. These beds were formerly worked with profit when mining was carried on on a small scale, and with the help of slaves. Now, however, minerals must be very rich and abundant to enable companies to make any return. Almost all those who have worked in the jurassic formation have been ruined. *Cuivre gris* or grey copper ore of good quality is found here as well as copper pyrites, both very argentiferous, but soon worked out. Near Barbadillo, at the extremity of the province of Burgos, at the foot of the Sierra de San Lorengo, a bed of this description is now worked, which, both for the richness and the quantity of the ore, is most promising. The non-argentiferous galena is generally more regular, and a few productive veins of sulphate and oxyd of antimony also occur, as, *c. g.* in the neighborhood of Ateca, in the province of Zarogoza.

In several places the rocks of the oolitic group have been affected by volcanic eruption, by which they have been altered, their color and structure changed, and all trace of fossil remains obliterated, so that it becomes difficult even for a practised geologist to classify them properly, Thus it is not extraordinary that travellers *en chaise de poste* have fancied that they saw in the centre of Spain variegated marls and red sandstones, trusting only to the external aspect of the rocks seen from the road. I am satisfied that further and more detailed observations will show that the oolitic and liassic formations are more extensively developed than has hitherto been supposed, *i. e.* that they will be discovered over a great portion of the south of the Peninsula.

Other phenomena, which further observation may perhaps tend to generalize, are the thermal springs which rise up in the jurassic formations at or near the point of junction with the more recent formations. We may mention, by way of example, the hot springs of Fitero in the province of Navarra, Arnadillo in the province of Logroño, and Alama near Calatayud. There are also cold sulphureous springs like those of Paracuellos in Aragon, and those of Gravalos in Castille. It must, however, be observed that these same phenomena also occur in the cretaceous formations, although not so frequently; amongst these latter

are the "Caldas de Catalogna," and the "Caldas des Asturias," with the geological conditions of which I am not quite acquainted, but I believe them to belong to the cretaceous beds. It is probable that similar cold sulphureous springs existed during the tertiary (pliocene) period; at least it is only by such a supposition that we can explain the origin of the vast deposits of sulphur which are worked at Hellin and Bénamaurel in the province of Albacete, and of that of Libros in the province of Teruel, the argillaceous beds of which are studded with *Planorbis* and *Limnæus* filled with native sulphur.

The Cretaceous formation covers the whole southern slope of the great chain of the Pyrenees, extending westward into the Basque country, to the mountains of Santander, and part of the Asturias. To speak more correctly, this cretaceous zone of the shore of the Cantabrian sea is rather a continuation of that which comes from France along the northern slope of the Pyrenees. The cretaceous zone of the southern slope also extends towards the west through Navarre, a portion of the Basque provinces, the province of Burgos, and the mountains of Léon, so that the great cretaceous deposit of the south of France and the north of Spain is divided in two by the transition and plutonic rocks of the Pyrenees, the jurassic rocks of Biscay, and the Devonian rocks of the Cantabrian mountain-chains. From Figueras in Catalogna to Oviedo in the Asturias is a distance of more than seven geographical degrees.

The Spanish cretaceous zone stretches towards the south with very little interruption, passing near Burgos, through Old Castille, the provinces of Soria and Guadalajara to Tamajon and Congostrina in the neighborhood of the celebrated mines of Hiendelencina, which we have already noticed. A ridge which passes by Segovia, the inclined strata of which rest against the granites of the Guadarrama, must be considered as a continuation of the same formation. The cretaceous beds probably exist more extensively in the centre of Spain, and particularly in the ancient kingdoms of Aragon and Valencia. I know only of a few particular spots, as in the province of Teruel, where they overlie the jurassic beds.

The cretaceous formations of central Spain also afford some phenomena which deserve the attention of the geologist. The most remarkable is the elevation of great tracts of country to a considerable height without losing their original horizontality, as the famous plain or plateau of Baraona, celebrated in the annals of Spanish fairies (Brujas or Witches), between Medinaceli and Almazan in Old Castille. It is nearly 5000 feet (1393 mèt.) above the level of the present sea. The plateau or table-land of Algora, province of Guadalajara, on the high road from Madrid to Zaragoza, corresponds to the white chalk (*craie blanche*), and is 4170 feet (1160 mèt.) above the sea. The village of Peñalcazar, in the province of Soria, bordering on that of Zaragoza, is built on a small plateau perfectly horizontal, whilst the neighboring hills consist of inclined beds of the same formation, and which nevertheless are not so elevated as the plateau itself. At Tamajon, in the province of Guadalajara, on the other hand, the horizontal portion is lower than the inclined beds. The same phenomenon, but on a larger scale, occurs in the valley of the Borunda, province of Navarre.

The great abundance of beds of lignite (*charbon*) distributed throughout the cretaceous formation of central Spain also deserves notice. In some respects they are not nearly as important as those of true coal (*houille*), but the fuel is often sufficiently good to be applied to all kinds of industrial purposes. It occurs at Rozas near Reynosa, at a spot not far from Burgos, at several places in the province of Soria, between the town of that name and Moncayo; in the Basque provinces, and perhaps also in the Asturias. The great saliferous deposits are also a peculiarity of our cretaceous formations; the celebrated mine of Cardona in Catalogna may be mentioned, as well as Pozo del Rey in the province of Burgos, the salt springs of Añana, province of Alana, which produce more than 50,000 fanegas of salt,* &c.

The formations of the tertiary period, both the marine and the lacustrine, overlie all kinds of beds of older date; as, for example, in Catalogna they rest on the chalk, at Valencia on the jurassic, in Andalusia on the transition beds, in the valley of the Guadalquivir, on the various surrounding beds and even on granite. The actual configuration of the Spanish soil must have been already marked out at the commencement of the tertiary period, with the exception of some partial modifications, for in general all the beds are in a horizontal position; Col. Silvertop only quotes along the coast of Andalusia some upheaved beds of the eocene period. It must however be observed, that along the same shore there are some spots, as at Cuevas de Vera Sierra Almagrera, where the marine tertiary formation attains an elevation of 900 feet, which gives rise to the question as to whether the waters of the Mediterranean reached that height before the Straits of Gibraltar were broken through, or whether the shore itself has been partially upraised since that period. Among the numerous fossils which are found on this coast, there are some species of mollusca of a most extraordinary size; in the vicinity of Cuevas de Vera are also found entomed the remains of elephants, isolated and distributed in particular directions, which were washed down by the streams into the ancient sea, all proving the existence at that period of a more tropical climate than is found at present in this district.

Our tertiary marine formations cover almost without interruption the whole shore of the Mediterranean, and even beyond the Straits in the province of Cadiz; I am not sure whether they extend into Portugal, although it is probable. This tertiary zone extends but a short distance into the interior, except in the valley of the Guadalquivir, where it may be traced without interruption from Cadiz and San Lucar, ascending the river, to Andujar and Liñares, where it rests upon granite, covering up the rich veins of galena which penetrate this plutonic mass of hills. On the northern slope the tertiary beds are but slightly developed. In the interior, I know of no marine tertiaries except in the neighborhood of Burgos towards the north, which must have been a salt lake at that period. In this formation we find a few deposits of lignite, the most important of which is probably that of Utrillas, near Montalvan, in the province of Teruel.

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* A *fanega* is equivalent to rather more than 99½ *litres* or 1·6 bushels; and a fanega of salt weighs about 112 Spanish pounds (or 113·6 lbs. av.).

In the third volume of our 'Annales de Minas,' published in 1845, I have given a general account of the great lacustrine formations of central Spain. The most important of all, and that which has been best examined, is what I have called the basin of the Douro (Cuenca del Duero), the surface of which is nearly forty Spanish leagues square,—3400 square kilom. To the west and south it rests on the crystalline or metamorphic formations of Galicia and of the frontiers of Portugal, of the Sierra d'Avila, and of the Guadarrama; to the north on the Devonian beds and on the chalk of the mountains of Léon; and to the east on the cretaceous beds. The lacustrine basin of the Ebro is also very considerable, but I do not know its exact limits. It is, perhaps, somewhat longer, following on both sides the course of the river; but it is not so broad. It rests almost everywhere on chalk, and partly on the jurassic beds. The basins of the Tagus and of the Guadarrama are separated from each other only by ramifications of the mountains of Toledo. The former, which is the most extensive, is placed exactly in the centre of Spain, and includes the capital. The fetid lacustrine limestone of Culmenar serves, as well as the granite of the Guadarrama, for architectural constructions, and is also used for statuary purposes, on account of its preserving almost indefinitely its natural whiteness. We also possess other small detached lacustrine deposits in the center of Spain, as *e. g.* at Libros near Teruel, at Calatayud, where fine specimens of sulphate of magnesia are collected, at Hellin and Bénamaurel, already quoted for the production of sulphur, at Molina d'Aragon with its *Neritina*, nov. sp., and several other localities.

It is well known that the surface of Spain is very mountainous and broken up. The only plain of any extent is that of La Mancha in New Castille, from Tembleque to Santa Cruz de Mudela, a distance of twenty leagues, and elevated more than 2000 feet above the level of the sea. All the other lacustrine plains of the tertiary period have been washed out and furrowed by ante-historic torrents, and by the great rivers which traverse them, which have carried off the greater portion of their mass, and have moreover cut out the ravines which surround the partial and isolated hills, the horizontal summits of which once formed the bottom of the ancient lake. Other plateaux, on the other hand, are, as we have already pointed out, the bottoms of the cretaceous ocean, which, while being upraised to a considerable elevation, have accidentally preserved their original horizontality. In all the other formations, and even in the cretaceous beds, the strata have generally been tilted in a thousand ways, dipping in every direction, and with every possible degree of inclination, being sometimes quite vertical and even partially reversed. On seeing all these upheavals, all these dislocations, and all the different characters of mountains which have resulted therefrom, it is at once evident that many instances of eruptive rocks must be looked for.

In point of fact our soil has never been at rest, nor is it so even at present. The plutonic eruptions which have pierced the gneissoid rocks have been already pointed out in the western districts; the euphotides, diorites, and black porphyries are more frequent in the central parts of Spain; and the trachytes are almost exclusively confined to the shores of the Mediterranean, and particularly to the southern por-

tion between Marbella and Carthagena. The remarkable and singular deposit of quicksilver of Almaden and Almadenejos must have been occasioned by the action of the euphotides and other analogous volcanic rocks which have burst forth in this district and moulded the mountains or Sierras in such a singular manner. The veins and other metalliferous deposits of Charthagena, Mazarron, and Sierra Almagrera, which yielded such wealth to the Carthaginians under Hannibal, and from which we still derive considerable benefit, are certainly contemporaneous with the basalts of Cabo-de-Gata and of Vera, and the trachytes of Mazarron.

Earthquakes are still often felt at Granada and along the coast of the province of Alicante, where their effects have been very disastrous. Much further in the interior, in the small Sierra del Tremédal or district of Albarracia, in the province of Teruel, eruptions and shocks have been frequent since the most remote periods; the black porphyry is there seen traversing the altered strata of the oolitic formation. The old inhabitants of the country speak of sinking of the ground and of the escape of sulphureous gases when they were young; these same phænomena have occurred during four consecutive months of the preceding winter, accompanied by earthquakes, which have caused considerable mischief to the buildings of seven villages situated within a radius of two leagues. They have not however been attended with any loss of life, on account of the inhabitants hastening to abandon their dwellings at the first indication of danger.

3. *Ascent of Popocatepetl*, (Athenæum, No. 1209.)—After describing the ascent, the following particulars are mentioned with reference to the crater.—The crater has somewhat the form of an irregular parallelogram, of perhaps a league in circumference, and four or five hundred yards in width. It is a vast barranca,—the bottom of which is strewed with large stones and masses of rock, which have detached themselves from the sides and top edge. From the point where we first saw it, it is about a thousand feet deep,—and the side is as perpendicular as walls. We were quite unprepared for so grand an object. In one part of the bottom we saw what appeared to be a small pond of sulphur,—which was boiling away at a great rate, and sending up a dense volume of smoke. This was fortunately carried to our lee by the wind,—otherwise we should have been half stifled. Most of the smoke deposits itself in the crater in the form of sulphur,—but a great body rises much higher. People who have reported that they had seen smoke issuing from the top have been hitherto doubted:—but there is now a good number of us ready to swear as to the activity of the volcano. The small pond of sulphur to which I have alluded, appeared, from the height at which we were, to be about two feet square. It afterwards became enveloped in the smoke; and finally was again visible,—but much larger than before,—say six or seven feet square. While we were admiring this sight, we heard a noise like thunder; and saw on the opposite side of the crater some large rocks detach themselves from the edge, and roll, or rather fall, to the bottom. This took away the desire to go down which we had previously entertained. During our stay at the top (about four hours and a half), we heard the same noise eight or ten times.

After admiring the crater for some time, we went down to the hut. T. set up his barometer, and we took the observations:—we also boiled water with a spirit lamp. It boiled at 184° Fahr.:—the barometer stood at 16·015 in., and the thermometer at 2° Centigrade. By both calculations, the elevation above the ocean is about seventeen thousand feet. We took observations the previous night at Hamacas:—the barometer showed 19·194 in., and the thermometer 11° Centigrade. Water boiled at 192° Fahr. This elevation is a little more than twelve thousand feet.

4. *On Hydrargillite with the Corundum of Pennsylvania;* by T. F. SEAL, (In a letter to one of the Editors, dated, Philadelphia, Feb. 3, 1851.)—In reading the last number of the Journal of Science I was much interested with Dr. Smith's paper on the Corundum and accompanying minerals of Asia Minor.

I have recently examined a mineral which we have long considered a steatitic coating on the corundum of Unionville, Pa. Alone, before the blowpipe, it instantly changes from its natural flesh color to a snow-white, and on the edges becomes enameled. With the cobalt solution, it gives a fine blue color. Although I am unable to get an analysis made at present, I think we may safely infer that it is the same hydrargyllite that occurs on the corundum of Asia Minor, as described by Dr. Smith in his memoir. He speaks of it as being rare. With us it occurs on a large proportion of the corundum crystals of the region. I have seen one crystal with this coating extending half an inch beyond the termination of the corundum and preserving the form of the corundum. Sometimes there is found on the *masses* of corundum a mammillary incrustation having a fibrous appearance which I take to be the same mineral. I have also found a thin coating of the albite rock of this locality having more distinctly the Gibbsite appearance. It appears as a *small mammillary* incrustation, (like the emerald-nickel of Lancaster Co., Pa.) of a grayish white color; before the blowpipe, with cobalt solution, it gives a bright blue very readily. I judge it to be the same mineral as the coating on the crystals of corundum.

The Unionville corundum has a higher specific gravity than that of Asia Minor. According to Mr. Joel Baily of Chester Co., it ranges from 3·90 to 4·10. I have many times looked for diaspore but without success. Some small crystals have the appearance of diaspore but they are too minute to make out their form. They do not decrepitate by heat, but according to Berzelius this is not a constant character.

5. *On Rhode Island Coal;* by A. A. HAYES, (From a letter to one of the editors, dated Boston, Feb. 3, 1851.)—Within a few weeks I have visited the Portsmouth company's coal mines on the island of Rhode Island, with reference to the economical use of the coal, and was much surprised to find so important beds, almost within our borders. About twenty-two thousand tons have been removed, fairly opening the workings, which can be so enlarged as to employ two hundred miners with every prospect of profit to a large amount.

The coal is in favor here for large fires and being sold at one fourth less price than that of Pennsylvania, meets a want which has long existed.

III. Zoology.

1. *Conspectus Crustaceorum quæ in Orbis Terrarum circumnavigatione, Carolo Wilkes e Classe Reipublicæ Fœderatæ Duce, lexit et descripsit* J. D. Dana.—Pars VI.*

Hyas lyratus.—Carapax† lyratus parce minutè tuberculatus, pone oculos alatè expansus, marginibus alæ antico posticoque subæquis, parallelis, margine externo excavato, rostro lævi, cornubus acutis, rectis. Pedes antici subtiliter pubescentes, brachio carpoque margines pustulatis, manu gracili. Pedes 8 postici longi, graciles, subtilissimè pubescentes.

Hab. ad oras Oregonenses.

Libidoclea coccinea.—Coccinea. Carapax orbiculari-triangulatus, sparsim tuberculato-spinosus et paulo subtiliter granulosus, rostro sat brevi. Pedes subtilissimè granulosi, tenues, digito paris 1mi subulato et basin non tumido, articulo paris 2di 3tio valde breviore quam carapax, tarsoque parce breviore quam articulus quintus, articulo 4to pedum 8 posticorum supra complanato et lævi. Articulus maxillipedis externi 3tius anticè integer.—Long. $2''$ $4\frac{1}{2}'''$.

Hab. in mari profundo juxta Patagoniam orientalem.

Genus PUGETTIA, *Dana*.—Rostrum, oculos, antennasque externas *Halimo* affinis. Articulus pedum 8 posticorum 5tus cylindricus.

Pugettia gracilis.—Mediocris. Carapax lyratus, paulo convexus, latus, pone oculos utrinque largè triangulato-expansus cum angulo acuto, margine postero-laterali spinâ crassâ armato, latitudine ante-medianâ vix minore quam latitudo post-mediana, regione medianâ tumidâ, minutè bituberculatâ. Pedes antici crassi, longi, brachio supra carinato, dentato, carpo bicarinato, digitis fere omnino contiguis. Pedes octo postici nudiusculi, articulis 3tio 5toque subcarinatis, 4to dorsum depresso, 5to infra versus apicem penecillum setarum brevissimum ferente.—Long. $16'''$.

Hab. in maris Oregonensis freto "Puget."

Pugettia Richii.—Sat grandis. Carapax subtriangulato-ovatus, pone oculos alatus, alâ bilobatâ, lobis acutis, posteriore elongato et fere transverso; spinâ laterali subposticâ grandi; regione medianâ 4 tuberculis spiniformibus armatâ, cardiacâ uno, postremâ uno, postero-laterali utrinque duobus. Pedes antici longi, crassi, brachio paulo tuberculato, margine antico subtilissimè scalpto, carpo valde cristato, digitis (*maris*) latè hiantibus, apicem denticulatis, digito mobili versus basin infra unituberculato.—Long. $2''$.

Hab. in mari juxta Californiam.—*W. Rich.*

Micippa hirtipes.—Carapax minutè pustulatus, marginibus lateralibus irregulariter paulo inciso-dentatis, rostro fere verticali, sub-polygonato, juxta antennam externam profundè constricto, apicem triangulatè emarginato, superficiem seriatim pustulato, pustulis setigeris. Oculi longè exserti. Pedes hirsuti.—Long. $7'''$; lat. $6'''$.‡ Long. rostri $3'''$.

Hab. in mari ad insulam Tongatabu.

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* Vide Partem I, in Nuntiis Acad. Art. Sci. Amer., i, 149; Partem II, ibid. ii, 9; Partem III, ibid. ii, 201; Partem IV, hoc op. [2], viii, 424; Partem V, ibid. ix, 129.

† Vocabulum "Carapax," auctoritate antiquâ non munitum, scientia rogat; masculinum, voce *thorace* exemplo.

‡ Carapaci non corpori dimensiones referendæ.

Genus CHORILIA, *Dana.*—*Pisæ Chorino*que affinis. Carapax angustus, triangulatè ovatus, gibbosus, paulo armatus, rostro longo, furcato, cornubus gracilibus. Oculi in orbitis retractiles. Antennæ externæ sub rostrum celantes, articulo primo angusto, apicem externum acuto. Orbita infra interrupta, supra angustè unifissa, spinâ præorbitali acutâ. Pedes 1mi 2dis breviores, 8 postici similes, 2di 3tiis non multo longiores. *Pisâ* quoad antennas externas celatas differt; *Chorino* pedes 2dos 3tiis non multo longiores, 1mos 2dis breviores.

Chorilia longipes.—Carapax nec villosus nec pubescens, latitudine trans-orbitali perangustâ, triplo minore quam latitudo carapacis maxima, spinâ præorbitali tenui, acutâ, margine orbitali superiore angustè unifisso; rostro longo, pubescente, cornubus fere rectis, parce divaricatis; regione medianâ 4 spinis brevibus armatâ aliisque paucis brevissimis; regione cardiacâ parvâ, inermi, 2–4 tuberculis parvulis ornatâ; regione postero-laterali spinâ crassâ mediocri armatâ aliisque tuberculis parvulis ornatâ. Pedes antici longi, brachio trigono, margines spinuloso; carpo polygonato, margines spinuloso; manu subcarinatâ, subtilissimè tomentosâ.—Long. 1″ 7‴; lat. 10‴.

Hab. ad oras Oregonenses.

Genus LAHAINA, *Dana.*—*Choriliæ* quoad pedes antennasque externas celatas affinis. Carapax elongatè ovatus, tumidus, parce armatus; rostri cornubus elongatis, gracillimis, divaricatis. Articulus antennarum externarum 1mus latus, parce longior quam latior, apicem processu spiniformi armatus. Orbita infra supraque sinu rotundato interrupta, dente præorbitali acuto. Pedes toti graciles.

Lahaina ovata.—Carapax vix spinosus, subvillosus, papillis postero-dorsalibus rectè flexis, spinâ postero-laterali parvulâ, aliâque posticâ; rostri cornubus corpore paulo brevioribus, tenuibus, valde divaricatis, margine orbitali superiore latè fisso, spinâ anticâ brevi acutâ et lateraliter unidentatâ, posticâ prominenter rectangulatâ non acutâ. Articulus antennarum externarum 1mus apicem spinigerus. Pedes tenues, longi, manu præangustâ, nudâ.

Hab. juxta insulam "Maui."

Genus SCYRA, *Dana.*—*Naxiæ* antennas orbitamque affinis. Rostrum laminatum, acutè furcatum. Articulus antennarum externarum primus undique angustus, apice externo ultra rostrum parce saliente; secundus depressus, tertio valde longior.

Scyra acutifrons.—Ovata, fere inermis, rostro brevi, cornubus ovato-lanceolatis, acutis, integris; spinâ præorbitali acutâ; regionibus carapacis valde prominentibus, regione medianâ aliisque profundè sejunctis, cardiacâ simpliciter rotundato-tuberculiformi. Pedes antici elongati, manu carinatâ, brachio angulos pustuloso, carpo 3–4-carinato.

Hab. in mari Oregonensi.

Genus CYCLAX, *D.*—*Mithraci* digitos affinis. Carapax suborbicularis, rostro parvulo, furcato. Oculi prælongi, retractiles, orbitis obliquè transversis. Antennæ externæ rostro remotæ, longæ, articulo primo apicem bi-spinoso, spinâ externâ longâ. Pedes longi; secundi carapace sesqui longiores; toti tenues, fere cylindrici.

Cyclax Perryi.—Carapax paulo oblongus, convexus, parce pustulatus, rostri cornubus subconicis, acutis, margine orbitæ superiore trispinoso, spinâ anteriore longiore et reflexâ, spinâ præorbitali parvulâ, post-orbitali crassiusculâ; marginibus carapacis antero-lateralibus 5-spinulosis, spinulis remotis, anteriore duplice; margine postico 2-spinuloso. Antennæ externæ dimidio carapacis longiores, pilosæ. Pedes carapace valde longiores, 8 posticis sparsim pilosis, tarso infra paulo piloso.—Long. $2\frac{1}{2}'''$.

Hab. in mari Vitiensi.

Eurypodius septentrionalis.—Carapax obsoletè villosus, spinis paucis, in regione cardiacâ posterius duabus anterius unâ; spinâ post-orbitali acutâ et anteriore minori vel acutâ vel obtusâ; rostro supra complanato. Articulus antennarum externarum 1mus dente subacuto extus ad basin armatus et juxta dentem processu subacuto. Pedes toti fere nudi; antici crassiusculi, brachio carpoque parce tuberculato-spinosis, manu scabro-granulatâ, paulo tumidâ, digito cum dente parvulo tuberculiformi intus armato polliceque juxta basin cum dente simili. Pedes 8 postici longi, articulo pedis tertii tertio tuberculis setiferis parvulis biseriatis infra ornato, 5to longiore quam quartus, subtilissimé hirsuto, ejus margine inferiore versus apicem brevissimè hirsuto.—Long. $2''\ 7\frac{1}{2}'''$; rostri $7\frac{1}{2}'''$; pedis secundi carapace plus duplo major.

Hab. in portu "Nassau" Fuegiæ.

Eurypodius brevipes.—*Feminæ*:—Carapax valde tumidus, spinis paucis, brevibus, in regione cardiacâ posterius duâbus anterius unâ; rostro supra complanato, breviore. Articulus antennarum ext. 1mus extus ad basin dente armatus et juxta dentem processu subacuto. Pedes breves, hirsuti, primi subtenues, brachio carpoque cum 3–4ve tuberculos minutos supra armatis, manu lineari, tenui, lævi, margine digiti interno denticulato. Pedes octo postici crassiusculi, valde breviores, articulo 3tio pedis secundi valde breviore quam carapax, articulo 5to lato et crasso, longiore quam quartus, non duplo longiore quam tarsus.—Long. $1''\ 7\frac{1}{2}'''$; rostri $3\frac{1}{2}'''$; coxæ pedis secundi $1''$, articuli 5ti $8'''$ ejusque lat. $2\frac{1}{2}'''$; tarsi $5\frac{1}{3}'''$.

Hab. in portu "Nassau" Fuegiæ.

Genus OREGONIA, *Dana*.—Rostrum, antennas, oculos, spinam postorbitalem pedesque elongatos *Eurypodio* affinis. Pedes tenues, octo postici articulum quintum aliosque subcylindrici, nunquam compressi.

Oregonia gracilis.—Carapax breviter sparsimque pubescens, rostro valde longiore quam latitudo inter-orbitalis. Pedes breviter sparsimque pubescentes, tenues; primi secundis paulo breviores, brachio tuberculis minutis supra infraque ornato, manu fere lineari, digito intus prope basin unidentato alioque denticulato. Abdomen *maris* sublineare, margine laterali versus apicem excavato, apice truncato.—Long. $1''\ 7'''$.

Hab. in maris Oregonensis freto "Puget."

Oregonia hirta.—Carapax pedesque sparsim hirti, rostro tenui, breviore quam latitudo inter-orbitalis. Pedes paulo breviores; digito pedis antici intus æque denticulato.—Long. $1''\ 5'''$.

Hab. in maris Oregonensis freto "Puget."

PERICERA TRIGONA.—Carapax bene triangulatus, triangulo equilaterali, spinâ postero-laterali longâ, crassâ, complanatâ; spinis dorsalibus duobus, unâ medianâ, alterâ cardiacâ; rostro mediocri, cornubus divergentibus; spinâ præorbitali perbrevi, subacutâ. Regio pterygostomiana uni-spinosa. Articulus pedum 3tius minutè tuberculatus et apicem plerumque spinoso-productus; manu tenui, digitis omnino contiguis.—Long. $1\frac{1}{4}''$.

Hab. in mari Vitiensi.

Genus TIARINIA, *Dana.*—*Pericerææ* orbitam antennasque affinis. Rostrum bifidum, cornubus plerumque contiguis. Carapax subpyriformis, tuberculatus aut pustulatus, tuberculo cardiaco tuberculis tribus aut pluribus facto. Articulus antennarum ext. 1mus latissimus, spinâ apicali non armatus, angulo externo-apicali interdum paulo saliente et subacuto. Orbita bene tubulata. Spina præorbitalis prominens. Pedes 1mi 2dis non longiores.—*Pericerâ*, cornubus rostri fere contiguis, formâ carapacis, et superficie aggregato-tuberculosâ, differt *Pericera tiarata* hîc pertinet.

TIARINIA GRACILIS.—Carapax pone oculos paulo constrictus, latitudine carapacis maximâ longitudinem post-orbitalem fere æquante, latitudine trans-orbitali sat majore quam dimidium latitudinis maximæ; rostro antennis externis breviore, cornubus apicem parce divergentibus, lateribus non dentigeris. Antennæ externæ ciliatæ, articulo primo angulum externum producto, subacuto, articulis secundo tertioque angustis, ad apicem parce latioribus. Manus tenuis, digitis omnino contiguis. Pedes 8 postici sparsim pubescentes, articulo tertio plus minusve tuberculato.—Long. $6'''$; lat. $3'''$.

Hab. in mari Suluensi.

TIARINIA ANGUSTA.—Carapax angustior, pone oculos vix constrictus, latitudine maximâ multo breviore quam longitudo post-orbitalis, latitudine trans-orbitali parce minore quam latitudo maxima; rostro longo, cornubus apicem conspicuè divergentibus, lateribus cum 3–4 dentes minutos remotos armatis. Antennæ externæ rostro dimidio breviores, articulis 2do 3tioque tenuibus. Manus tenuis, digitis omnino contiguis. Pedes 8 postici pubescentes, secundi 3tiis duplo longiores. Articulus 3tius paris antici plus minusve tuberculatus.—Long. $6'''$; rostri $2'''$; lat. $2\frac{1}{2}'''$.

Hab. in mari Suluensi.

Genus PERINIA, *Dana.*—*Pericerææ* affinis. Orbita anticè paulo aperta eoque non bene tubulata, margine superiore non unifisso. Articulus antennarum ext. 1mus oblongus, anticè non latior, apicem externum paulo productus. Rostrum breviusculum, cornubus divaricatis. Carapax tumidus, paucis tuberculis tumidis ornatus.

PERINIA TUMIDA.—Carapax valde tumidus, brevis (lat. maximâ long. post-rostralem æquante) lateribus rotundatis, regione medianâ convexâ minutè bi-tuberculatâ, regione cardiacâ largè tuberculiformi, laterali tumidè tri-tuberculatâ. Rostrum breve, latitudine trans-orbitali fere duplo brevius. Spina præ-orbitalis brevis, subacuta. Pedes breves, articulis 3tio 4toque spinosè tuberculatis, manu crassâ, digitis latissimè hiantibus, digito mobili prope basin unidentato.—Long. $3\frac{1}{2}'''$; lat. plus $3'''$.

Hab. in mari juxta insulam Hawaiiensem "Maui."

Menæthius angustus.—Carapax sat tuberculatus, perangustus (latitudine multo minore quam longitudo post-rostralis), dentibus lateralibus tribus, duobus anticis bilobatis; rostro longo, emarginato; regione medianâ tumidâ, posticè bituberculatâ et anterius areâ triangulatâ notatâ; regione post-medianâ brevi, uni-tuberculatâ; regione intestinali grandi unituberculatâ, margine postico rotundato, integro.—Long. $5\frac{1}{2}'''$; lat. $3'''$.

Menæthius areolatus.—*M. subserrato* affinis. Carapax paulo tuberculatus, tuberculo cardiaco simplice, quoque post-mediano intestinalique simplicibus; rostro integro, mediocri, margine laterali dentibus tribus, primo simplice, secundo paulo duplice. Oculi apicem rotundati et spinâ anticâ alterâque posticâ instructi. Manus oblonga, superficie subtilissimè areolata, digitis plerumque contiguis, denticulis sex. Pedes 2di 1mis longiores.—Long. $2'''$.

Hab. in mari Suluensi.

Menæthius inornatus.—Carapax latus, latitudine trans-orbitali dimidio minore quam sive latitudo maxima sive longitudo post-rostralis, pone oculos non constrictus; marginibus lateralibus 3-dentatis, dentibus triangulatis subacutis; rostro brevi, integro; spinâ præorbitali latè triangulatâ; superficie dorsali paululum gibbosâ, regione cardiacâ simplicissimè tuberculatâ, medianâ tumidâ, vix subdivisâ, regione laterali fere planâ. Oculi parce salientes, apicem bene truncati.—Long. $5'''$; rostri $1'''$; lat. $4'''$.

Hab. in mari juxta insulam Hawaiensem "Maui."

Acanthonyx simplex.—*Feminæ: A. Petiverio* affinis. Carapax parce convexus, tuberculis omnino carens, marginibus lateralibus parallelis, posterius cum dentibus duobus obsoletis ornatis, dente post-orbitali nullo. Pedes antici reliquis parce crassiores, digitis plerumque contiguis, 7–8-denticulatis, denticulis triangulatis, carpo supra cristato, subacuto; paris postici articulus penultimus angustior, angulo inferiore basi nec apici propiore, (in *Petiverio* apici nec basi propiore). Tarsus 8–10 spinulis armatus.—Long. $9'''$; lat. $5\frac{2}{3}'''$.

Hab. ad insulas Hawaienses.

Acanthonyx debilis.—*Petiverio* affinis. Carapax paulo convexus, marginibus lateralibus parallelis, regione medianâ obsoletè bi-tuberculatâ, tuberculis setigeris. Pedes antici *maris* reliquis vix crassiores. Digitis parce hiantibus, carpo non cristato. Tarsus pedis postici 12–14 spinulis seriatim armatus; articulus penultimus latè triangulatus, infra obliquè truncatus.—Long $9'''$; lat. $5\frac{2}{3}'''$.

Hab. ad oras Chilenses.

Genus PELTINIA, *Dana*.—*Epialto Acanthonyci*que affinis. Carapax latus, sublævis, depressus, rostro brevi complanato, profundè bifido, latitudine transorbitali grandi, quam dimidium carapacis vix angustiore, dente præorbitali prominente, antero-laterali valde producto, postero-laterali parce prominente. Antennæ externæ rostro non celatæ, articulo primo angusto, apicem non dentigero. Oculi non retractiles, breves. Pedes 1mi 2dis breviores. Articulus 8 pedum posticorum penultimus fere cylindricus infraque non gibbosus.—Antennis apertis Epialto differt, Acanthonyce congruit; articulo pedum 8 posticorum penultimo subcylindrico Acanthonyce differt. Latitudo transorbitalis Antilibiniæ latitudine duplo major; quoque dorsum depressum, rostrum profundius furcatum.

PELTINIA SCUTIFORMIS.—Carapax subscutiformis, paulo oblongus, lævis, rostro vix longiore quam latiore, bilobato, angulis antico-lateralibus valde productis setigeris, diametroque gastrico maximo. Margine postero-laterali dentibus duobus obsolescentibus setigeris notato, regione medianâ bi-tuberculatâ. Antennæ externæ rostro valde longiores. Pedes tenues, antici inermes, digitis contiguis.—Long. 2‴.

Hab. in portu "Rio Janeiro."

PELTINIA NODULOSA.—Carapax suboctagonus, parce oblongus, lævis, angulis duobus lateralibus utrinque productis, obtusis, rostri cornubus triangulatè sejunctis, triangulatis, subacutis; dente præorbitali subacuto, post-orbitali obsoleto, margine postico inermi. Pedes nudi, mediocres, articulis totis manu tarsoque exceptis, plus minusve nodulosis, tarsis infra minutè spinulosis. Antennæ externæ apicem rostri parce superantes.—Long. 3‴.

Hab. in mari Vitiensi.

HALIMUS TUMIDUS.—Rostri cornua subconica, latè divaricata. Carapax valde tumidus, latere 4–6 spinulis minutis armato; regione medianâ tribus tuberculis parvulis triangulatè ornatâ, alio tuberculo obsolescente posteriore; regione cardiacâ tuberculis obsolescentibus notatâ. Pedes pubescentes, sat breves; manu tenui, basin latiore, digitis fere contiguis, tenuibus; articulo 5to pedis postici duplo longiore quam latiore. Articulus antennarum ext. 1mus apicem externum valde productus extusque 2–3-spinulosus.—Long. 7‴.

Hab. ad oras Australiæ orientalis.

HUENIA SIMPLEX.—*Maris*:—Carapax lævis, valde elongatus, angustè subtriangularis, lateribus antero-lateralibus longis, anticè convergentibus fere rectis et integris, in latera rostri rectè productis, dente præorbitali nullo, rostro oblongo, valde obtuso, angulo postero-laterali subacuto; margine postico integro; superficie 4-tuberculatâ, (regione medianâ 3-tuberculatâ, cardiacâ 1-tuberculatâ.) Pedes antici validi, manu crassâ, digitis latissimè hiantibus; articulus pedum 8 posticorum penultimus subcylindricus.—Long. $9\frac{1}{2}$‴.

Hab. ad Insulas Hawaienses.

HUENIA BREVIROSTRATA.—*Feminæ*:—Carapax latus, paulo oblongus, breviter rostratus, utrinque 2-angulatus, angulis salientibus, lateribus inter angulos laterales valde excavatis; superficie carapacis breviter 4-tuberculatâ, rostro ad basin valde angustiore quam frons, acuto, non longiore quam latitudo transorbitalis, dente præorbitali vix saliente, obtuso. Manus tenuis, digitis versus basin paulo hiantibus, carpo inermi; articulus pedum 8 posticorum penultimus subcylindricus.—Long. $7\frac{1}{2}$‴.

Hab. ad Insulas Hawaienses.

LEUCIPPA LÆVIS.—Carapax subtriangulatus, lævis, regione medianâ parce tumidâ, rostro elongato, furcato, cornubus triangulatis, et triangulatè sejunctis, acutis; marginibus carapacis lateralibus pertenuibus, paulo expansis et subreflexis, 4-dentatis (aut angulatè undulatis), dentibus inæquis, dente posteriore posticè arcuato, hoc margine in superficiem regionis postero-lateralis producto. Regio pterygostomiana 3-dentata (aut instructa uno dente in sinu grandi insito). Pedes nudi, articulo 3tio cristato.

LAMBRUS RHOMBICUS.—Carapax paulo transversus, medium latior, subrhombicus, lateraliter posticèque arcuatus, pone oculos non constrictus; superficie inæquali tuberculis parvulis parce ornatâ, regione laterali super basin pedis secundi tuberculo conico armatâ, posterius altero minore; rostro apicem pubescente. Pedes antici margines hirsuti, manu trigonâ, marginibus salientibus inæque dentatis, brachio marginem anticum minutè eroso et superficiem minutè spinuloso. Pedes 8 postici gracillimi, breviter pubescentes.—Long. 10‴.

Hab. in Archipelago Vitiensi, mari Pacifico.

CERATOCARCINUS? SPECIOSUS.—Carapax hexagonus, fere equilateralis, depressus, regionibus partim conspicuis, fronte lato, rectè transverso, subtiliter crenulato, medium emarginato, utrinque juxta oculum valde saliente. Manus digitusque mobilis spinulosi; carpus parce spinulosus; digiti contigui. Pedes 8 postici breviter pubescentes, inermes. —Long. $1\frac{1}{2}$‴.

Hab. in Archipelago Vitiensi, mari Pacifico.

2. *Zoological Researches;* by JOSEPH LEIDY, M.D. 1850.

(1.) *On American Annelida abranchiata,* (Jour. Acad. Nat. Sci., ii, 43.)—This memoir contains descriptions of the following species from the vicinity of Philadelphia.

Nais rivulosa.
Nais gracilis.
Pristina longiseta, *Ehrenb.*
Strephuris (*Leidy*) agilis.
Aeolosoma venustum.
Enchytræus vermicularis, *Henle.*
Enchytræus socialis.
Lumbriculus limosus.
Leucophrys clavata.

The new genus *Strephuris,* is described as follows:—Podal spines alternating with setæ, in two rows. Upper lip moderately projecting. Girdle well marked. Number of articulations not over seventy. No muscular stomach. Blood bright red.

The paper is accompanied with a lithographic plate illustrating with details the species described.

(2.) *On two New Genera of Fossil Mammalia,* (Proc. Acad. Nat. Sci., Philad., v, 90.)—The species are named *Eucrotaphus Jacksoni* and *Archæotherium Mortoni;* they are from the vicinity of Fort Laramie.

(3.) *Contributions to Helminthology,* (Proc. Acad. Nat. Sci. Philad., v, 96.)—The species here described are—

Ligula Tritonis.
Pentastomum Didelphidis Virginianæ.
Pentastomum Euryzonum, *Diesing.*
Pentastomum proboscideum, *Rud.*
Echinorhynchus ovatus.
Echinorhynchus tortuosus.
Echinorhynchus Pici collaris.

(4.) *Notes on the development of the Gordius aquaticus,* (Proc. Acad. Nat. Sci., v, 98, Oct., 1850.)

(5.) *Two new species of Infusorial Entozoa,* (Ib., p. 100.)—The species are *Nyctotherus ovalis* and *Bodo Julidis.*

(6.) *Description of some Nematoid Entozoa infesting Insects,* (Ib., p. 100.)—Species:

Streptostoma gracile.
Thelastoma appendiculatum.
Thelastoma labiatum.
Thelastoma robustum.
Oxyuris socialis.
Hystrignathus rigidus.

(7.) *Descriptions of three Filariæ,* (Ib., p. 117.)—Species:—Filaria Hominis oris, F. canis cordis, F. Boæ constrictoris.

(8.) *On the nettling organs of the Hydra*, (Ib., p. 119.)

(9.) *New Fossil Mammalia from Missouri*, (Ib., p. 121.)—Species :—Palæotherium Bairdii, Rhinoceros nebraskensis, Merycoidodon Culbertsonii, Agriochœrus antiquus.

The species of Palæotherium described in this Journal, vol. iii, p. 248, 2nd Ser., is called P. Proutii.

(10.) *New Species of Vermes*, (Ib., 124.)—Species :—

Peloscolex (*Leidy*) variegatus.
Chætogaster gulosus.
Rhynchoscolex (*Leidy*) simplex.
Emea (*Leidy*) rubra.
Anortha (*Leidy*) gracilis.

3. *Value of the word Species in Zoology ;* by S. G. Morton, M.D., (Proc. Acad. Nat. Sci., Sept. 10, 1850, v, 81.)—On the value of the word *species*, there is great diversity of opinion among naturalists. Some deny the law of specific distinctions—at least their arguments lead to this inference. Thus, Lamarck and Geoffroy St. Hilaire insist upon the uninterrupted succession of the animal kingdom—the gradual mergence of one species into another, from the earliest ages of time : and they suppose that the fossil animals whose remains are preserved in the various geological strata, however different from those of our time, may nevertheless have been the ancestors of those now in being. Sir Charles Lyell has opposed this theory with great ingenuity and general success ; yet whoever will examine the facts and arguments employed by its authors, may be disposed to admit that it is not altogether devoid of foundation in some exceptions to the general law of Nature.

Somewhat allied to this is the opinion of Swainson and others, that permanent varieties constitute species, or in other words, that variations of climate, food and treatment produce specific distinctions.

Species is defined by Buffon, "a succession of similar individuals which re-produce each other." Cuvier's definition is nearly the same ; but he adds that "the apparent differences between the races of our domestic species are stronger than those of any species of the same genus. The fact of the *succession*, therefore, and of the constant succession, constitutes alone the validity of the species."

An objection to these definitions arises from the fact that they apply as readily to mere varieties as to acknowledged species. Certain albino animals re-produce, *inter se*, to an indefinite extent ; such also is the case with some fanciful varieties of the dog, pigeon, &c., which are capable of multiplying by the law of succession, and yet have no claim to specific distinction, in the restricted acceptation of that term.

I have brought together these definitions, in the first place to show that naturalists are by no means agreed upon what constitutes a species, and secondly, to offer some views of my own.

As the result of much observation and reflection, I now submit a definition which I hope will obviate at least some of the objections to which I have alluded. Species—*a primordial organic form.* It will be justly remarked that a difficulty presents itself, at the outset, in determining what forms are primordial ; but independently of various other sources of evidence, we may be assisted in the inquiry by those monumental records, both of Egypt and Assyria, of which we are now happily possessed of the proximate dates. My view may be briefly explained by saying, that if certain existing organic types can be traced back into the "night of time," as dissimilar as we see them now, is it

not more reasonable to regard them as aboriginal, than to suppose them the mere accidental derivations of an isolated patriarchal stem of which we know nothing? Hence, for example, I believe the dog family not to have originated from one primitive form, but from many. Again, what I call a species may be regarded by some naturalists as a *primitive variety*; but, as the difference is only in name, and in no way influences the zoological question, it is unnecessary to notice it further.

These views appear to correspond with those of Mr. Linnæus Martin, who expresses himself in the following terms:

"We are among those who believe that, as there are degrees in the relationship of species to species, some may, although distinct, approximate so nearly as not only to produce *inter se*, mules incapable of interbreeding, but *a progeny of fertile hybrids, capable of admixture, even to the most unlimited extent?*

Species may therefore be classed according to their disparity or affinity, in the following provisional manner:

Remote species of the same genus, are those among which hybrids are never produced.

Allied species produce, *inter se*, an infertile offspring.

Proximate species produce with each other a fertile offspring.

IV. Astronomy.

1. *The new planet Egeria*, (Gould's Astron. Jour., No. 21.)—This planet was discovered by Mr. Gasparis of Naples in Italy, on the 2d of Nov. 1850. The discoverer having requested M. Le Verrier to name the planet, the latter has proposed to designate it *Egeria*, which name will of course be adopted. The body resembled a star of the 9th or 10th magnitude, and belongs to the group between Mars and Jupiter. The following elements of its orbit are by M. G. Rümker.

1850, November	2·0 Greenwich, m. t.	
Mean longitude,	288° 37′ 17″·0	
Long. of perihelion,	116 26 49 ·4	m. Eqx. 1851.
" " Asc. node,	43 35 24 ·4	
Inclination,	15 57 59 ·8	
Angle of excentricity,	5 31 9 ·38	
Log. semi axis major,	0·4082517	
Log. of mean daily motion,	2·9376290	

V. Miscellaneous Intelligence.

1. *Magnetism;* (Proc. Roy. Soc., Dec., 1850; Athenænm, No. 1206.)—The Bakerian Lecture was delivered by M. Faraday, Esq., illustrated by experiments. After alluding to the experiments of Padre Bancalari, the lecturer showed the opposite magnetic condition of oxygen and nitrogen; the former when inclosed in a bubble of glass is always attracted by the magnet, the latter repelled. In common with iron and some other metals, oxygen loses its magnetism on the application of heat, and regains it on again becoming cold. In this fact Mr. Faraday finds the cause of the diurnal movements of the magnetic needles all over the world, as exhibited at the respective observatories; and he

explains the apparent anomalies which occur at St. Helena and Singapore on the hypothesis induced from the whole of the phenomena. The lecturer, in closing, stated that the explanation was to be received as conjectural, although, at present, sufficiently satisfying the theory.

2. *A comparative examination of the objective glasses of Microscopes from Mr. Ross of England, Mr. Spencer of America, and M. Nachez of Paris;* by J. LAWRENCE SMITH, (communicated for this Journal.)—Having had an opportunity a short time since, while at Paris, to examine the comparative merit of the lenses of these makers, it might not be uninteresting to microscopists to know the result of my examination, particularly as it was made under peculiar circumstances; namely, by adapting alternately the objectives to the same mounting, and regarding the same object under the same illumination.

The glasses used were considered by their makers as among their best. That made by Ross was in the possession of M. Rutherford of U. S. Spencer's was owned by Dr. Burnet of Boston, and had just been brought by him from Spencer. That of Nachez belong to Dr. Bigelow of Boston, now in Europe engaged in microscopic research very creditable to himself. Their magnifying powers varied from thirteen hundred to fifteen hundred diameters, with an ocular magnifying ten times; Ross's was the feeblest, that of Spencer the strongest.

The angular opening was first measured with great accuracy and found as follows:—

Ross, ...	145°
Spencer, ...	135°
Nachez, ...	120°

These measurements were all verified by the respective owners of these lenses.

The objects examined were the most difficult test-objects among the siliceous infusoria, as the Navicula angulata, one of the species of Gramatophora, and a Navicula called the Amici test. The first two were in balsam.

The lenses were first attached to one of Nachez's mounting, and the best adjustment of oblique light used that this instrument affords. The difference in the effect of the three lenses was very slight, all failing to show the lines on the Gramatophora or on the Amici test. As notwithstanding the admirable arrangement of Nachez's instrument for working purpose, we do not get the extreme obliquity of light which is required for examining their fine lines, I had them all arranged on a mounting of Amici, which furnishes the necessary obliquity of light. Thus arranged, the lines on the Gramatophora were distinctly and beautifully seen by all, with slight advantages in favor of Spencer and Ross, the former of which magnified them most.

The Amici test was next tried which resulted in Ross showing the lines with perfect satisfaction; Spencer showing them, but not quite so well; Nachez still less distinctly.

I would remark that this difference between the lenses appears to be owing entirely to difference in the angle of opening, for where a very oblique light is necessary to show lines, the lenses must be so constructed as to admit this light. I would also state that Nachez's system

lacks an adjustment which the others have, by which the relative position of the lenses can be changed, so as to compensate for the thickness of the glass which covers the object, and which appears favorable to the examination of those delicate tests. For the examination of globules we could not perceive any appreciable difference between the lenses.

I would here remark in justice to M. Nachez that he deserves much praise for the manner in which he has improved the microscope in France, without augmenting the cost of the instrument, and out of England he is undoubtedly the best maker in Europe. To furnish an idea of what he has done to diminish the cost of a good instrument, I will compare the price of the objectives which have been the subject of the experiments.

Ross, ...	306 francs.
Spencer, ...	230 "
Nachez, ...	60 "

and what is still more, he is constantly improving his lenses without adding to their expense.

The lower powers of these makers were examined, without finding any sensible difference in the defining effects of them, and what little there was, was in favor of Spencer. The field of the three differed, Nachez's being the least, and Spencer's the greatest. We cannot bestow too much praise on our American maker, for the immense progress which he has made in the construction of objective lenses, and it is to be regretted that he has not chosen a better mounting for them, than that of Chevalier, which is very defective and prevents good glasses from showing their best effects.

I had intended making some remarks on oblique light, which has come very much in use lately in observing lines and points on certain objects, but it will be better for me to defer it. I would simply remark that much caution is necessary in using it, as it will not always give correct distances between lines.

3. *Logeman's Magnets.*—As the magnets of W. M. Logeman are remarkable for their power, we insert here a list of his prices, received from him in a letter dated Haarlem, Sept. 22, 1850.—Eds.

A list of the prices of my magnets was published some months ago by Prof. Poggendorff at Berlin in his Annalen der Physik und Chemie. They are as follows:

No.	Force of attraction in Prussian pounds.	Price in florins.	No.	Force of attraction in Prussian pounds.	Price in florins.
1.	25	10	5.	150	95
2.	40	17	6.	200	128
3.	80	42	7.	300	170
4.	120	78	8.	400	240

A Prussian pound is equal to 1·031 English pounds, and two Dutch florins are equivalent to one dollar. Straight bars of every size for magnetical observations, of the same relative force as the above horse shoe magnets, are afforded at very moderate prices.

A horse shoe magnet of 500 pounds force can be made at a price but little higher than one of 400 pounds, at least, it will not cost above three hundred florins.

The forces of attraction given above are the *constant* forces of the magnets, which will not diminish by repeatedly and abruptly forcing the armature from the poles.

4. *Albuminizing Photogenic Glasses*, (Athenæum, No. 1205.)—We have received from Dr. Maunoir a translation, made at the request of M. Scarpellini—the President of a Society having its meetings on the Capitol, called *Romana Corrispondenza Scientifica*,—of a paper published in the Society's Journal by M. Luigi Ceselli, on a new process for "albuminizing photogenic glasses." It appears to point out a method by which extreme uniformity in the thickness of the film may be obtained:—and we print it from Dr. Maunoir's manuscript, with a few verbal alterations where there appears to be a want of clearness, arising from the difficulty which a foreigner writing in English must necessarily experience when not thoroughly familiarized with the idiom of the language.

It cannot be denied that photography has gained much by the substitution of glass for photogenic paper; as thus has been obtained a high degree of transparency of the plates for the process, a modification of that applied by Daguerre to the grand discovery of the celebrated Neapolitan, Gio. Batt. Porta, which discovery remained forgotten for nearly two centuries. Many difficulties, however, still existed; for, with the use of glass, a layer of albumen was necessary to the production of those wonderful results obtained by the rays of light. Again, to cover the glass with a layer of albumen of equable thickness, so that the light may produce everywhere the same effect, to prevent any inequalities forming on the surface during the drying process, to produce the layer at one stroke,—such were the difficulties which, notwithstanding repeated experiments, yet remained to be overcome and had retarded the progress of this wonderful new method,—but which, it seemed to M. L. Ceselli, did not deserve to be abandoned, to be replaced by the improvements obtained with photogenic paper.

After having studied the various processes in use, M. L. Ceselli invented a small simple machine, which he has found to obviate every difficulty.

It consists of a small rectangular box, supported by three regulating screws. To its base is joined a moveable plate of metal, which, being heated by means of a lamp of alcohol, communicates to all parts of the box an equal degree of heat. The plate is removed when the water-bath is to be used instead of the lamp. The apparatus is protected by a glass covering, to guard against heterogeneous bodies falling on the albumen. This cover is also moveable; and the box being traversed by an internal channel, in this, when convenient, a thermometer may be introduced. A sliding frame receives the glass which is to receive the preparation; this, again, being placed between two other plates of glass. The glasses are secured and their edges brought to correspond by means of a tightening screw,—so that the albumen, when either spreading or shrinking, may always cover the whole surface of the intermedial plate of glass. The frame is furnished on two parallel sides with a small groove to receive the albumen,—which a small round edged knife, elevated to the proper point by means of two spiral pivots cased in the sides of the box, and kept down in a parallel

direction to the glass by means of a screw, serves to remove, producing by this means the exact thickness of layer which is required. The frame is furnished along one of its sides with an indented ridge, to which a wheel provided with an external handle corresponds, so that the frame can be made to move with such velocity as the operation may require.

5. *New Method of Engraving Plates for Printing Ferns, Sea Weeds, &c.*, (Athenæum, No. 1207.)—At a recent meeting of the Sheffield Literary and Philosophical Society, Dr. Branson read a paper describing this process.—His mode of operation is to place a frond of fern, alga, or similar flat vegetable form, on a thick piece of glass or polished marble; then taking and softening a piece of gutta percha, of proper size, and placing on the leaf and pressing it carefully down, it will receive a sharp and accurate impression from the plant. The gutta percha retained level, and allowed to harden by cooling, is then handed to a brass caster, who reproduces it in metal from his moulding vase. This, it will be obvious, is the most delicate and difficult part of the process, and one which, a few years ago, would not, we suspect, have been executed in Sheffield. As it is, Dr. Branson has had many brass plates thus produced from sand-casting, which required only a little surface-dressing to yield, at once, under the copper-plate printing-press, most beautiful as well as faithful impressions of the original leaves: indeed, many of the exhibited specimens of ferns, printed in green color, and slightly embossed, as they must needs be by the printing, were such perfect fac-similes of the natural pattern, that they might easily be taken for it. Besides these matters, the doctor exhibited a large variety of patterns of embossed leather, which had been produced by a somewhat analogous operation. As, however, this latter invention is not so much for copying designs as for creating them, and at the same time, saving all the expense of die-cutting, the following is the course pursued:—The operator takes a piece of common hard white soap of the required size and surface, and upon that executes any design, whether of the depth and boldness of ordinary embossing or in the delicate lines of an etching; in either case the work is executed with the greatest ease. From this soap-model or engraving, an impression is taken in gutta percha; from *that* a secondary one, which on being cast in brass, as before, may be used for printing or embossing in the ordinary way. The reader stated that his main difficulty was in getting the last gutta percha coat to separate from the mould of the same substance into which it was pressed. He had found, however, that by powdering both the surfaces with common bronze dust, before taking the impression, they did not adhere.

6. *On Sugar in the flowers of Rhododendron ponticum.*—Prof. George Jæger of Stuttgardt writes us that the existence of cane sugar in the flowers of the Rhododendron ponticum, announced as ascertained by Dr. B. Shlamer in volume x, p. 113 of this Journal, was first determined by him and published in the year 1825 in the Zeitschrift für Physiologie von Tiedemann and Treviranus, vol. xi, p. 173, and is cited from him by Gmelin in the third edition of his Hand-book of Chemistry, vol. ii, p. 733.—Eds.

7 *On British Eocene Serpents and the Serpent of the Bible*; by Professor OWEN, (Jameson's J., xlix, 239, from Owen's British Reptiles.) —A few bones of serpents have been found in the superficial stalagmite, and in clefts of caves, in peat bogs, and the like localities, which bring their occurrence and deposition within the period of human history. None of these Ophidian remains, however, have offered any differences in size or other characters from the corresponding parts of the skeleton of our common harmless snake (*Coluber natrix*). As yet, no Ophidian fossils have been found in British fresh-water formations of the pre-adamitic or pleistocene period, from which formations the remains of the Mammoth, Tichorrhine Rhinoceros, great Hippopotamus, and other extinct species of existing genera of *Mammalia* have been so abundantly obtained. Between the newest and the oldest deposits of the tertiary period in geology, there is a great gap in England, the middle or miocene formations being very incompletely represented by some confused and dubious parts of the crag of fluvio-marine origin in which teeth of a mastodon have been found.

The deposits in which the remains of the large serpents of the genus *Palæophis* occur so abundantly, carry back the date of their existence to a period much more remote from that at which human history commences. Yet, as the strange and gigantic reptiles that have been restored, and, as it were, called again to life, from times vastly more ancient, realize, in some measure the fabulous dragons of mediæval romance; so the locality on our shore of the English channel in which the Eocene serpents have been found in most abundance and of largest size, recalls to mind, by a similar coincidence, the passage cited by an accomplished and popular historian, in his masterly sketch of the rise and progress of the English nation. "There was one province of our island in which, as Procopius had been told, the ground was covered with serpents, and the air was such that no man could inhale it and live. To this desolate region the spirits of the departed were ferried over from the land of Franks at midnight."*

The discovery of serpents of different genera and species, some, as *Paleryx*, terrestrial, and all manifesting the peculiar and characteristic vertebral organization of true *Ophidia*, at a period incalculably remote from that at which we have any evidence of the existence of man, more forcibly recalls our early ideas of the nature and origin of serpents derived from annotations to Scripture which represented them as the progeny of a transmuted species, degraded from its originally created form as the consequence and punishment of its instrumentality in the temptation of Eve.

"The curse upon the serpent," say the learned Drs. D'Oyly and Mant, in the edition of the Bible printed under the direction of the Society for the promotion of Christian Knowledge, ed. 1823, "consisted, 1*st*, in bringing down his stature, which was probably, in great measure, *erect* before this time; 'upon thy belly shalt thou go,' or, 'upon thy breast,' as some versions have it: 2*dly*, In the meanness of his provision, 'and dust shalt thou eat,' insomuch as creeping upon the ground, it cannot but lick up much dust together with its food."

* Macaulay's History of England, vol. i, p. 5.

The idea of the special degradation of the serpent to its actual form, derived from interpreting the sentence upon it as a literal statement of fact, has been so prevalent as to have affected some of the zoological treatises of the last century. Thus, in the quaint and learned "Natural History of Serpents," by Charles Owen, D.D., 4to, 1742, p. 12, the author, treating of the food of those reptiles, writes,—"That dust was not the original food of the serpent seems evident from the sentence passed upon the Paradisaic serpent, but the necessary consequence of the change made in the manner of its motion, *i. e.*, the prone posture of its body, by which it is doomed to live upon food intermixed with earth."

Dr. Adam Clark, commenting more recently upon the record in its literal sense, seeks to elude the difficulties which thence arise, by contending that the Hebrew "Nachash," may be translated "Ape," as well as "Serpent." But when we find him reduced to the necessity of glossing the text by such expositions, as that to go on the belly, means "on all fours;" and by affirming, of the arboreal frugivorous four-handed monkeys, that "they are obliged to gather their food from the ground," we have a lively instance of the straits to which the commentator is reduced who attempts to penetrate deeper than the Word warrants, into the nature of that mysterious beginning of crime and punishment, by the dim light of an imperfect and second-hand knowledge of the divine works.

If, indeed, the laws of the science of Animated Nature formed part of the preliminary studies of the theologist, the futility of such attempts to expound the third chapter of Genesis, viewed as a simple narration of facts, would be better appreciated by him; and if he should still be prompted to append his thoughts, as so many lamps by the side of the second text, he would most probably restrict himself to the attempt to elucidate its symbolical signification.

What zoology and anatomy have unfolded of the nature of serpents in regard to their present condition, amounts to this:—that their parts are as exquisitely adjusted to the form of their whole, and to their habits and sphere of life, as is the organization of any animal which, in the terms of absolute comparison, we call superior to them. It is true, the serpent has no limbs, yet it can outclimb the monkey, outswim the fish, outleap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird upon the wing; thus all these creatures fall its prey. The serpent has neither hands nor talons, yet it can outwrestle the athlete, and crush the tiger in the embrace of its ponderous overlapping folds. Far from licking up its food as it glides along, the serpent lifts up its crushed prey, and presents it, grasped in the death-coil as in the hand, to the gaping slime-dropping mouth.

It is truly wonderful to see the work of hands, feet, fins, performed by a simple modification of the vertebral column in a multiplication of its joints, with mobility of its ribs. But the vertebræ are specially modified, as I have already described, to compensate, by the strength of their individual articulations, for the weakness of their manifold repetition and of the consequent elongation of the slender column.

As serpents move chiefly on the surface of the earth, their danger is greater from pressure and blows from above; all the joints are accordingly fashioned to resist yielding, and to sustain pressure in a vertical direction; there is no natural undulation of the body upwards and downwards, it is permitted only from side to side. So closely and compactly do the ten pairs of joints between each of the two or three hundred vertebræ fit together, that even in the relaxed and dead state the body cannot be twisted, except in a series of side coils.

Of this the reader may assure himself by a simple experiment on a dead and supple snake. Let him lay it straight along a level surface; seize the end of the tail, and, by a movement of rotation between the thumb and finger, endeavor to screw the snake into spiral coils; before he can produce a single turn, the whole of the long and slender body will roll over as rigidly as if the attempt had been made upon a straight stick.

When we call to mind the anatomical structure of the skull, the singular density and thickness of the bones of the cranium, strike us as a special provision against fracture and injury to the head. When we contemplate the still more remarkable manner in which these bones are applied one over another, the superoccipital, overlapping the exoccipital, and the parietal overlapping the superoccipital, the natural segments being sheathed one within the other, the occipital segment within the parietal one, we cannot but discern a special adaptation in the structure of serpents to their commonly prone position, and a provision of the dangers to which they were subject from falling bodies, and the tread of heavy beasts. I might enumerate many other equally beautiful instances of design and foresight,—the whole organization of the serpent is replete with such—in relation to the necessities of their apodal vermiform character; just as the snake-like eel is compensated by analogous modifications amongst fishes, and the snake-like centipede amongst insects.

But what more particularly concerns us in the relation of the serpent to our own history, is the great and significant fact revealed by palæontology, viz., that all these ophidian peculiarities and complexities of cranial and vertebral organization, in designed subserviency to a prone posture and a gliding progress on the belly, were given by a beneficent Creator to the serpents of that early tertiary period of our planet's history; when, in the slow and progressive preparation of the earth, the species which are now our contemporaries were but just beginning to dawn; these, moreover, being species of the lowest classes of animals, called into existence long before any of the existing mammalia trod the earth, and long ages before the creation of man.

8. *Indiana Cave*, (New Albany Ledger, Ind.)—We are just informed by N. J. Coleman, Esq., who has recently visited the great Indiana cave, that another immense cavern has been discovered opening from the original cave, which in extent, curiosities, and mineral productions, far surpasses the old cave. Mr. Coleman discovered an aperture, just before reaching Jacob's Ladder, into which a large man could hardly enter, and desired the party which accompanied him to explore it. The guide and two or three of the party objected, as the aperture appeared to descend rapidly, and they feared they might meet with bad

air. By a little persuasion however, they were prevailed upon to make the exploration. With much difficulty they descended some forty feet, when to their great astonishment, they found themselves in an immense apartment. They immediately determined fully to explore the cave they had discovered. They found that this room opened into others, and these into still others, and that apparently, there was no termination to the cave. They followed the main passage some four or five miles according to their best calculation, when they were admonished by their lights that they must return. On their way back, they visited some of the rooms which they had passed, in which they had found large beds of epsom salt, in nearly a pure state. We are also informed that the cave contains fine specimens of saltpetre, plaster of Paris, alabaster, &c., of which the party procured many fine specimens.

It seems then, that Indiana has a cavern which far surpasses the Great Mammoth, as the last discovery in connection with the great Indiana cave will make it one of the largest in the United States.

It is about eleven miles from Corydon in a southwest direction, and about seven north of Leavenworth.

9. *On the Blue Licks Spring, Licking River, Ky.*; by Prof. Robert Peter, M.D., Transylvania University.—Saline, and saline sulphur-waters, are comparatively frequent in our blue limestone strata; but among all the springs of this nature, known at present on this formation, in Kentucky, none are as valuable and as remarkable, in many respects, as those of the lower Blue Licks.

The principal spring of this locality, from which the water submitted to analysis was taken, is situated near the banks of the Licking river, flowing out about twenty feet above low water in that stream. It rises in a hexagonal basin of stone which has been built for it, which is six feet two inches in diameter from one side to the opposite parallel one, and about five or six feet in depth. The quantity of water which flows out varies in different seasons. When the water for the present examamination was obtained, June 6, 1850, it was low in the spring and not running. The water in this basin was lowered about one foot by pumping out seventy six barrels,* in the course of three hours; and in the winter time the stream which flows out from it would probably fill a pipe three inches in diameter.

The temperature of this spring was observed by Major Richard Owen, Professor in the Western Military Institute located at the Blue Licks. In six observations, at different times on June 4th and 5th, the external air varying from 60 degs. to 76 degs. Fahr., the temperatnre of the water stood very constantly at 62 degs. This is about seven degrees above the mean temperature of this region, which is about 55 degs.; and it is probable that the temperature of the water in the basin had been somewhat raised by the external heat of the atmosphere. When flowing rapidly it may perhaps be found to approximate more nearly to the mean annual temperature.

On standing exposed to the air, the water becomes of a yellowish-green color, very perceptible in a white pitcher, or even in a white

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* These barrels will not contain more than thirty gallons.

glass bottle. This color deepens on boiling the water,—but boiling does not cause it to appear in the recent water.

Besides sulphuretted hydrogen and carbonic acid which are dissolved in the waters or escape insensibly, streams of bubbles of gas are continually rising through the spring and breaking into the atmosphere. Some of this *gas*, carefully collected for me by Maj. Owen, in bottles prepared for the purpose, was submitted to analysis, and found to consist mainly of nitrogen, mixed with about 4·5 per cent. of carbonic acid gas, containing only a trace of sulphuretted hydrogen.

The analysis of the water was performed in the chemical laboratory of the Medical Department of Transylvania University, at Lexington, with the assistance of Mr. A. Schue, of the Western Military Institute.

The composition of the Blue Lick water; according to this analysis, is as follows; calculated both in 1000 grains of the water and in the wine pint of 7·680 grains, viz.:

Specific gravity 1·007.

Gases	in 1000 grains.		In the wine pint.	
	Grains.	Cubic inch.	Grains.	Cubic inch.
Sulphuretted hydrogen gas,	0·03947	0·1086	0·303129	0·834048
Free carbonic acid gas,	0·3547	0·76	2·724096	5·8368

The former is in the proportion of about 1·36th the volume of the water and the latter about 1·5th the volume.

Saline contents	in 1000 grains.	In the wine pint.
Carbonate of lime,	0·3850000 grains.	2·9568000 grains.
Carbonate of magnesia,	0·0022065 "	·0169459 "
Alumina, phosphate of lime and oxyd of iron,	0·0058330 "	0·0447974 "
Chlorid of sodium,	8·3472930 "	64·1072102 "
Chlorid of potassium,	0·0226690 "	0.1740979 "
Chlorid of magnesium,	0·5272000 "	4·0488960 "
Bromid of magnesium,	0·0009394 "	0·0302546 "
Iodid of magnesium,	0·0007340 "	0·0056371 "
Sulphate of lime,	0 5533300 "	4·2495744 "
Sulphate of potash,	0·1519190 "	1·1166738 "
Silicic acid,	0·0179400 "	0·1377792 "
Loss,	0·2819861 "	2·2158335 "
Whole saline contains,	10·3000000	79·1040000

The water also contains traces of oxyd of manganese, and apocrenic and crenic acids.

Taking the data above given as to the quantity of water which flows out at this spring, we find that it emits 678 gallons in the day of twenty-four hours. Supposing the saline matters to constitute but one per cent. of the water, the amount brought out in one hour would be more than 58 lbs. avoirdupois. But say that 50 lbs. an hour is the proportion, and the quantity will amount to 438,000 lbs. per annum. The specific gravity of common salt being 2·257, this quantity in solid lump would contain about 310 cubic feet, or be enough to form a cube of salt nearly seven feet on a side! And yet the water flows on without any

sensible diminution of its saltness. Whence is all this saline matter obtained? Is there, imbedded in the deeper strata of the blue limestone, an immense layer of rock salt, derived from the original ocean, under which the rock was deposited?

10. *Wingless Bird*, (Proc. Linn. Soc., Dec. 17, and Athenæum, No. 1209.)—Mr. Westwood called the attention of the Society to the existence of a wingless bird on Lord Howe's Island,—an island situated between New Holland and Norfolk Island. This spot had been accidentally visited by Capt. Poole of the East India Company's service; who considering it a favorable spot for colonization, had induced six Irishmen and their wives and families to settle on it. The place is now one of constant resort for the supply of water and provisions to the South Sea whalers. As no Government has owned it, this island is at present the property of Capt. Poole. It is of considerable extent, and has on it two high hills which can be seen at a distance of sixteen leagues at sea. On this island Capt. Poole had discovered the bird in question. It is about the size of a rail,—and is considered by the settlers as good eating. Mr. Westwood thought the announcement of the existence of this bird—which was not previously known to exist in those regions—would be received with interest in connection with the discovery of the extinct wingless birds of New Zealand. No specimen has yet arrived in England,—but some are on their way.

11. *Vegetable Physiology*, (L'Institut, No. 878.)—MM. Cloës and Gratiolet operated in their experiments upon aquatic plants, as different species of Potamogeton, Naias, Ceratophyllum, Myriophyllum and Confervas. The following are some of their results.

a. Influence of light.—The disengagement of oxygen from the green parts of the plants is very rapid in full solar light, insensible in diffuse light, and null in darkness, and in the last condition *no* carbonic acid is disengaged, contrary to an old opinion but now for some years correctly understood. With glass of different colors, the effect was greatest with colorless glass, and diminished in the order, red, green, blue.

b. Influence of temperature.—The decomposition of carbonic acid by aquatic plants exposed to light under a temperature of +4° C., does not commence until the temperature is raised to 15° C., and has its maximum at 30° C.; and if the plants are in a temperature of 30° C., then on its reduction, action continues even to 10° C. This result corresponds with Chevreul's on the circulation and ascension of the sap of plants.

c. Influence of the composition of the surrounding waters.—In river water, deprived of air by ebullition and containing only carbonic acid in the same proportion as the waters of the Seine, the water being frequently renewed, the decomposition is at first active, but afterwards diminishes and ceases after four to five days; and by this time the green color of the plant has become paler. At first the gas produced is mixed with some nitrogen, the quantity of which goes on diminishing, so that when the decomposition ceases, the air disengaged is almost wholly pure oxygen. The total volume of the nitrogen disengaged is much more considerable than the volume of the plant, and on submitting this plant to elementary analysis, it is found that for equal weights, it contains much less nitrogen than a portion of the same plant not sub-

jected to the experiment. The facts show that in the act of growth in submerged plants, nitrogen proceeds from the decomposition of the elements themselves of the plants; that consequently a resupply is necessary and consequently nitrogen free or combined is essential to the life of the plant. In the experiments instituted by Cloës and Gratiolet, a ten-thousandth of ammoniacal salts dissolved in water always proved injurious. The decomposition of carbonic acid diminished and ceased after some hours; whence the conclusion that the plant assimilates directly nitrogen in solution in water. They have also found that whatever may be the position of the leaves of Potamogeton in the water, carbonate of lime is decomposed by the superior surface of the leaves and never by the inferior. They have also ascertained that the oxygen produced by the decomposition of the carbonic acid has a definite course—that it descends invariably from the leaves towards the roots. Thus when a stem of a Potamogeton is placed horizontally in water, the emission of the gas always takes place by the section nearest the root end of the plant.

12. *Anæsthetic Action*, (L'Institut, No. 886.)—M. Aran has made experiments on the anæsthetic action of certain agents used as an external application to the skin, and has found that the best material for this purpose is chlorated chlorohydric ether. The sesquichlorid of carbon may also be used, but whilst the ether operates effectually in a few minutes, at least two hours are required to produce insensibility with the sesquichlorid. To produce the desired effect, from 15 to 30 drops of the pure chlorated chlorohydric ether suffice; they are put upon the part in pain, or upon a piece of linen cloth which is to be immediately applied to this part, and the contact is maintained by a bandage; and quickly the pain is relieved. A pomatum of this ether may also be employed consisting of 4 grammes to 20 of suet; or if of the sesquichlorid of carbon, 4 of this agent to 30 of suet; it may be used either with friction or without. The insensibility is not simply cutaneous, for it gradually extends to the parts beneath.

The chlorated hydrochloric ether is obtained by the action of chlorine on hydrochloric ether, by which, compounds containing chlorine in increasing proportions are formed, isomerous with the series of bicarburets of hydrogen, and identical with the same series in the density of the vapor for corresponding compounds. It is a colorless liquid, of an ethereal aromatic odor analogous to chloroform, and a sweetish and even peppery taste at times; hardly soluble in water, but wholly so in alcohol, sulphuric ether, and most of the fixed and volatile oils. It is without action upon paper of tournsol; is not inflammable; has a variable density and a variable point of ebullition, oscillating between 110° and 130° C., showing that the material is rather a mixture of several ethers than a single simple substance. All the chlorated chlorohydric ethers have the same anæsthetic properties, and they cannot be separated completely from one another.

13. *On Telegraphs, and on Gutta Percha as a means of insulation and a material for models*; by Prof. C. G. Page, (Report to Commissioner of Patents, Patent Office Report, for 1849, p. 405.)—A variety of inventions under this head, have been presented to the office, most of them based upon the electro-magnetic telegraph. Prominent among

these is the electro-chemical telegraph. Two patents have been granted for inventions of this kind, one of which has already gone into practical operation, to a considerable extent. These inventions were adjudged by the office to interfere with each other, and upon a hearing, priority of invention decided in favor of one of the parties. Upon appeal however, to the usual tribunal, it was decided that the alleged interference did not exist, and patents were ordered to be issued to both parties. The whole case was one of unusual interest, involving many intricate and important questions, and although the whole proceeding was prior to your accession to the office, yet the leading features are doubtless by this time familiar to you. The parties, Sam'l F. B. Morse and Alexander Bain, came into the contest for priority of invention upon unequal grounds, the former being a citizen of the United States, and the latter a foreigner. It was held by your predecessor in office, that under the law a foreigner could not go behind his foreign patent or printed publication for evidence of his invention, and upon reference of this subject to the Attorney General, the opinion of the commissioner was confirmed. It was also held that in a contest for priority of invention, the sealing of a foreign patent was not to be taken as proof of invention, and that proof of enrolment was alone adequate. On the appeal to Chief Justice Cranch, the parties appeared by counsel, who occupied some days in elaborate argument. It was, I believe, the first trial of appeal from the office, had in open court, and the whole case has been faithfully reported and printed at the expense of one of the parties. The report will be read with much interest by inventors and professional men.

The operation of the electro-chemical telegraph depends upon the chemical re-agency of the galvanic current. Marks or stains are made upon paper through which the galvanic current is made to pass, the paper being first saturated with some neutral or other salt, and moistened at the time to give it sufficient conducting power. The advantage claimed for this over the electro-magnetic telegraph, is that it may be worked with much greater rapidity. In the electro-magnetic telegraph a signal is made by the development of electro-magnetism, and the consequent movement of a small bar of iron, both of which operations require appreciable time. In the chemical telegraph the production of the stains or marks is commensurate with the passage of any portion of the galvanic current; for, according to the best authorities, the current could not pass through the salt without decomposition. The change of colors, as indicated to the eye, may not be so sudden as the transit of the current, but if it should not be so in fact, it becomes so practically, as the marks are not required to be seen at the instant of decomposition. I am not informed upon this point, but it is immaterial; the practical distinction between the chemical and electro-magnetic telegraph being this, that as it requires time to change and discharge an electro-magnet, and also to overcome the inertia of moving parts, there must be a limit in practice to the rapidity of making signals, while in the electro-chemical telegraph, the limitation would depend upon other causes, and the rapidity of action would probably far exceed the ordinary mechanical facilities for communicating signals. With a view to avail himself of this greater capability of this telegraph over the other,

one inventor has pattented a means of preparing and transmitting communications much more rapidly than the ordinary manipulations with the kev. To accomplish this, strips of paper are perforated by machinery, in such a manner that the perforations may correspond to the signs representing the letters, figures, or words, and by means of these perforations and the intervening spaces, or whole portions of the paper, the circuit is broken and closed with as great rapidity as a slight spring pressing upon a strip of paper can be made to act. It is only necessary that the motion of the paper at the other end of the line which is to receive the communication should move with a corresponding rapidity. In practice it has been found that the rapidity of execution is much less than it should be theoretically; but nevertheless it is far greater than with the electro-magnetic telegraph. With this, as with all the plans for telegraphs hitherto undertaken, a difficulty of some importance has been encountered, from the imperfect insulation of the wires, although great pains have been taken to render the insulation as complete as practicable, and several patents have already been taken out for telegraphic insulators. As the insulated supports for the wires have to sustain a considerable weight, they must be made of a corresponding strength; and, moreover, as they have been made the sportive targets of lawless boys, and objects of less wanton though more malicious mutilation by mischievous men, it has been found necessary to give a due share of attention to strength and safety in this respect, and in so doing some sacrifice of insulating properties have been thus far deemed necessary. A curious result follows from this want of insulation. If it be assumed that the air is impervious to galvanic electricity, all that can return to its source between two distant stations, without travelling the whole distance, must pass down each post on the line, and can reach the post only through the substance of the insulating material employed, or along its surface in case it should be moist. A greater amount of electricity will pass down those posts nearest the station where the battery is in operation, and at the extreme end of the line only a feeble portion will pass through the instruments. The consequence of this has been, that upon the conductors being moistened upon their surfaces, the instruments at the distant stations would work with unequal power, and occasion much embarrassment. This difficulty is in some measure remedied, by having batteries at each end of the line, or at every station, although the defective insulation still exists for each. I am inclined to think however, that the air, when loaded with moisture, is a conductor of galvanic as well as of mechanical electricity, as indicated by my experiments, several years since, with the immense copper roof of the Patent Office, forming a great galvanic plate of upwards of 20,000 square feet of surface. If it is sufficiently so to be of practical value, it is obvious that entire insulation of telegraphic wires will be difficult to accomplish.

The *crossing of rivers* and large bodies of water, by means of submerged wires, does not seem yet to have been attained, and the chief obstacle thus far is imperfection in the methods of insulation. The plan which I proposed several years since appears to be worthy of trial. It consists in using a local circuit and battery of quantity at each river or body of water. The galvanic current employed on the main

routes are of small quantity and high intensity ; hence a slight defect of insulation in a submerged wire would be productive of a great loss. But by using a current of quantity and the lowest possible intensity, to be set off by a local magnet, I am inclined to think that a single wire laid in the river with the most ordinary preparations for insulation, would be effectual in establishing connection between the terminations of the great line on opposite sides of the river or other body of water. It has long since been proposed to connect the eastern and western continents by means of telegraphic wires laid down in the depths of the ocean, and lately the proposition has been revived with a venturesome and true American spirit. It does not appear in any way impracticable to stretch a wire from the American continent to England; and in the waveless depths of the interminable waters, the wire would be more secure from depredation than on *terra firma*. From its weight it would sink beneath the realms of the living monsters, and lie far out of reach from the ruthless hand of mischief or speculating avarice. But the insulation of such a wire is a thing not easily conceived of, in the present state of our knowledge. Besides the mechanical niceties required to obtain a complete insulating covering for the wire, we should have to contend against the corrosive action of the sea water, and this too, at a point where its greater density would exalt its chemical agency.

Much has been expected and promised from *gutta percha* as an insulator, but we have not been long enough acquainted with this curious substance to test its value for this purpose. It is indeed a most excellent electric and insulator, but I have seen several instances of its decomposition when exposed to air and moisture, and some cases of its entire destruction when in thin sheets. I have been recently informed that the decay of thin sheets of gutta percha is attributed to caustic materials used in preparing it ; however this may be, I have seen supports for telegraphic wires made from the pure gum, undergo in one season decomposition to such a depth as to form a bibulous mass upon its surface, and materially impair its non-conducting property. It resists, however, to a remarkable degree the action of strong acids, and may be used with great convenience for funnels, syphons, &c., for transferring and holding even strong nitric acid. It may not be out of place here to mention its unfitness, when in very thin sheets, for models of patented inventions. During the past year a patent was granted for a surgical instrument, an essential part of which was a sac of gutta percha. In the course of a few months the entire sac had disappeared, having crumbled into powder.

American Indicating Disc Telegraph.—An instrument under this name has been patented, which presented some ingenuity and novelty in the mechanical arrangements, and also in the selection and use of signals. It is an optical or indicating telegraph, as its name purports, and in this particular, must yield to the recording telegraphs. The signs are indicated by the figures **0**, **1**, **2**, **3**, **4**, these being the only symbols used. These stand for the vowels, and the remaining letters are represented by combinations of these figures. The figures are arranged in four sets, upon the face and near the circumference of a disc, which revolves by means of a novel internal escapement, which is moved by a lever attached to the armature of an electro-magnet. Its language is less complex than that of other indicating telegraphs.

Pen Telegraph.—When Prof. Morse's telegraph was first essayed in this city, it recorded the signs upon a moving fillet of paper by means of a pen charged with ink, the pen being supplied from a reservoir or fountain. It was found difficult to regulate the flow of the ink, more especially as the motion of the pen was apt to *throw* the ink, as it was termed, and the pen was accordingly dispensed with, and a contrivance substituted, by which marks corresponding with those made by the pen were indented upon the fillet of paper. This required some mechanical force, and it became necessary to have a local registering magnet, as it is called, of some power to supply this force. In the new pen telegraph the inventor has ingeniously reversed the order of Morse's telegraph, and moves the paper to the pen which is kept stationary, thus obviating the difficulty of throwing the ink and requiring a slighter force to move the paper than is now required to indent the paper. The pen is also fed by an ingenious contrivance. A lever or arm carrying a feeder which dips into a fountain of ink, is operated at the requisite intervals so as to move up to the pen and deposite upon a proper amount of ink, and then retire again to the fountain to recharge. This arm carrying the feeder is actuated by the clock work which is used to move the fillet of paper. It was thought that this invention would save the necessity of using a receiving magnet, and that the telegraphing might be performed directly by the use of one magnet merely to move the paper to the pen. If, however, it fails to supersede the receiving magnet, it can have no advantage to recommend its use.

14. *On the Purification of Coal Gas;* by Mr. Laming, (Proceedings of the Society of Arts, April 24th, 1850; from Chem. Gazette, June 1st, 1850, p. 218.)—The ordinary method of purification by lime is confessedly very imperfect, as it removes but very little of the ammonia, and the refuse is very offensive in its odor and from its great quantity becomes a nuisance. The advantages of the new process are that it removes every trace of ammonia and sulphuretted hydrogen, and that the materials do not require to be periodically renewed. It consists in a mixture of oxyd of iron and chlorid of calcium, which the author prepares by decomposing a saturated solution of muriate of iron with lime or chalk and then mixing it with fine coal or saw-dust to give the mass the necessary permeability. The iron in the mixture becomes rapidly peroxydized from its porosity and from the spontaneously elevated temperature of the mass.

On placing this, instead of lime, in the purifiers, the impure gas containing sulphuretted hydrogen, in part or wholly combined with ammonia besides carbonic acid, converts by the action of the sulphuretted hydrogen the peroxyd of iron into sulphuret of iron and water, while the liberated ammonia forms a carbonate with the carbonic acid, and the latter salt with the chlorid of calcium forms salammoniac and carbonate of lime. When no more oxyd of iron and chlorid of calcium remain undecomposed, the mixture is exposed for a time to atmospheric air, which converts the sulphuret of iron into sulphate; this reacting with the carbonate of lime yields sulphate of lime and carbonate of iron which by the atmospheric oxygen is rapidly converted into hydrated peroxyd with the escape of carbonic acid.

The mixture now differs from the original only in containing in place of the chlorid of calcium a sulphate which acts in precisely the same way. The regeneration of the used materials is effected in an hour or two and the author has already repeated it fifteen successive times. It becomes at last necessary to wash out the salt of ammonia, when the material regains all its pristine force.

By this process all impurities, even the sulphuret of carbon, are removed, with a large portion of carbonic acid, while the increase of the illuminating power is estimated at eight per cent. The cost of materials is slight, while the impurities are converted into merchantable articles, and the wear and cost of apparatus is reduced to a minimum.

These results have been verified by experiments at Paris and successfully carried out on a large scale at the gas works at Westminster.

T. S. H.

15. *On the Asphaltic Coal of New Brunswick;* by C. T. Jackson, (Proc. Bost. Soc. Nat. Hist., April, 1850, p. 279.)—On the 16th of last March, Henry W. Fuller, Esq. of Boston, sent me a box of specimens of a new kind of fuel recently discovered in New Brunswick. It was regarded as cannel coal of a peculiar kind.

This substance proved to be a very beautiful variety of asphaltum. It is jet black, glossy, and free from smut. It breaks with a broad conchoidal fracture like obsidian, and presents a brilliant surface.

It is a little softer than rock salt, which scratches its surface. Its specific gravity is 1·107.

It softens and melts when exposed to heat in close vessels. When inflamed it does not run, but burns freely with a bright yellow flame and a little smoke. Heated in a glass flask, it gives off an abundance of bituminous liquid analogous to petroleum, and leaves a very light and bulky coke of a brilliant black color and very porous. When exposed to heat in a covered platinum crucible, an abundance of carburetted hydrogen gas is given off, which burns with a large and brilliant yellow flame, having a high illuminating power.

The asphaltum is but slightly acted upon by alcohol or by ether, yielding a little yellowish matter, which is obtained by evaporation of the solution. Oil of turpentine dissolves a considerable quantity of the asphaltum, forming a varnish such as is used by engravers.

Weighed portions of the asphaltum were taken for analysis, and on being heated in a covered crucible so as to expel all the volatile matter, the coke remained and was weighed. The results of two trials gave,—

1st.	2nd.
58·5 of volatile matter.	58·8 of volatile matter.
41·5 of coke.	41·2 of coke.
100·0	100·0

The coke obtained was burnt on a platinum tray, placed in a red-hot muffle, and left 0·47 per cent. of ashes, of a deep reddish brown color, consisting of peroxyd of iron with a little oxyd of manganese, and silica, and alumina.

The discovery of this valuable fuel so near to our borders is a matter of congratulation. The bed is stated to be four to six feet in thickness, and if it holds out for any considerable extent, it must supply an enormous amount of fuel. This substance is particularly valuable for the production of gas for illumination. It is also the best fuel for steam engines, and is particularly well adapted for the use of locomotive steam engines on railroads.

I have not visited the spot where this asphaltum is found, but, having seen it associated with gypsum from Dorchester, N. B., am led to believe that it occurs above the coal formation of New Brunswick.

[The facility with which this asphaltic coal melts down in the gas retorts has hitherto, we are informed, been an obstacle in the way of its use.—EDS.]

16. *Shooting Stars of August*, 1850.—M. QUETELET states that according to the facts observed, the number of shooting stars per hour on the evening of the 9th of August, was about 60 for Brussels; on the evening of the 10th, 111 for Brussels, 180 for Markree, Ireland, and 58 for Rome. The direction was the same for all these places.

17. *Lalande Medal*, (Athenæum.)—The Academy of Sciences at Paris has awarded the Lalande medal to M. de Gasparis for his discovery of the planet Hygeia in April, 1849. The prize for 1850 was shared between Gasparis for his discovery in November of two planets, and Mr. Hind for his discovery on the 13th of September of the planet Victoria, (Clio.)

18. *Academy of Natural Sciences of Philadelphia. Extracts from the Reports of the Librarian and Curators for the year* 1850, (Proc. Acad., v, 127, 129, 132.)—"The additions to the Library, of all descriptions, during the present year (1850) amount to 2965, this number being more than double that of 1849, and far exceeding the ratio of any previous year since 1834. The subjoined table has been prepared in the ordinary form, presenting the number of volumes, pamphlets, and works in parts or numbers, on each subject.

Subject.	Number of volumes.	Periodicals in parts, numbers, &c	Pamphlets.
General Natural History,	151	40	36
Mammalogy, - - -	12	1	14
Ornithology, - - -	78	35	27
Entomology and Crustacea,	191	23	56
Ichthyology and Herpetolgy,	9	4	19
Conchology and Helminthology, - - - -	48	56	52
Geology and Mineralogy,	105	21	57
Botany, - - - -	9	9	7
Anatomy and Physiology,	141	55	127
	744	244	395

Subject.	Number of volumes.	Periodicals in parts, numbers, &c	Pamphlets.
Brought over, - -	744	244	395
Physical Sci. and Chemistry,	10	1	10
Medicine, - - - -	3	. .	15
Trans. and Proceed. of Soc., Journals, Annals, &c., &c.,	622	334	8
Voyages and Travels, -	147	136	7
Geography, - - -	26	. .	2
Dictionaries of Arts and Sci.,	110	. .	. .
Bibliography, - - -	23	. .	17
Miscellaneous, - - -	34	. .	77
	1719	715	531

Of the whole number 2965, there have been contributed by authors 74; by editors 18; by members, correspondents, and others 109; by societies and corporations 113; by Dr. Wilson 2493; by Mr. Edward Wilson, of Wales, 153; by the U. S. Treasury Department 5 (charts)."

"The increase in the cabinet during this year, will be briefly noticed under the head of each respective department.

Mammalia.—In this class, the Academy has been greatly enriched by the addition of the collection of Dr. J. K. Townsend, made by himself in the Rocky Mountains and Oregon, consisting of 37 species, 56 specimens, in skin, in a good state of preservation. These were liberally presented to the Society by Dr. Townsend. Most of them are the specimens from which the species were originally described, and many of them are exceedingly rare in natural history collections, and a few are unique. Among them are two specimens of the gigantic wolf of America, *Lupus gigas*, lately described by Dr. Townsend in the Journal of the Academy.

We have also received skins of twenty species of mammalia, of Europe, Asia, Africa, and Australia, from W. E. Strickland, Esq., of England, through Dr. Wilson.

Another addition of great value was made by Dr. T. B. Wilson, consisting of one hundred specimens from the collection of the Prince of Canino, C. L. Bonaparte, being the originals of the species figured and described in the Fauna Italica.

We are also indebted to Capt. W. McMichael for 7 species, 8 specimens, of animals from Van Diemens Land.

Besides the above there were presented to the Society ten species from various sources.

Aves.—We have received during the year 71 bird skins, of which 51 are from Van Diemens Land, presented by Capt. W. McMichael; 10 from China, presented by Capt. John Land; the remainder from various localities, presented by Dr. E. J. Lewis, and others.

The valuable Des Murs collection of Bird's eggs, containing 1281 species, mentioned in the last report of the Curators as a deposit, has since been presented to the Academy by Dr. Wilson.

To Mr. Samuel Ashmead we are indebted for a donation of 38 species, 48 specimens, of American bird's eggs.

There were also presented by various individuals, principally members of the Society, 15 species of nests, and 23 of eggs, from different localities.

Reptilia.—Of reptiles there have been received 65 species, 80 specimens, besides numerous American duplicates, principally from Dr. McCartee, of Ningpo, China; Capt. John Land; Mr. Sandwith Drinker, of Hong Kong, China; and Mr. Ashmead.

Pisces.—In ichthyology, the cabinet has received, rather unexpectedly, a large and very valuable collection, presented by Dr. T. B. Wilson, consisting of 767 bottles containing fishes in alcohol, and 177 dried specimens of the latter, formerly belonging to Prince C. L. Bonaparte, and being the originals of the descriptions and illustrations of the Fauna Italica.

From other persons we have received eleven species of fishes, principally American.

Mollusca.—In this department there have been presented 107 species of shells, from various localities, principally by Mr. Ed. Verreaux, of Paris, Dr. McCartee, of China, and Messrs. E. T. and Chas. W. Wilson.

Insecta.—A fine collection of Brazilian insects, consisting of 484 species, 981 specimens, has been added to our cabinet through the lib-

erality of Henry Bond Dewey, Esq., of Para, Brazil, through Dr. Henry Bond, of this city.

To Dr. McCartee, also, we are indebted for the gift of 120 species, 216 specimens, of Chinese insects. Other collections have also been received, but without definite number, in exchange or by donation, principally from Drs. Heerman, Townsend, and Watson.

The collection of insects of the Academy is arranged in boxes in the form of large quarto volumes, with glass on the two sides, so as to permit the objects to be viewed from above and below without disturbance. The Lepidoptera now arranged amount to 979 species, 1692 specimens.

Crustacea, Myriapoda, and Arachnida.—A large collection of Crustacea has been presented to the Academy by Dr. Wilson, consisting of 381 species, 749 specimens, from all parts of the world.

There have been received, also, nine species from different persons.

Ten Spiders and three Myriapods were presented by Dr. McCartee, of Ningpo.

Echinodermata.—Of Echini and star fishes we have received 21 species, 41 specimens, chiefly from Mr. Edward Wilson, and Messrs. Harwick and Argent, of London."

The Report continues with statements of additions correspondingly large, in the departments of Comparative Anatomy, Botany, Palæontology and Mineralogy.

President for 1851, Samuel George Morton, M.D.; *Vice Presidents*, J. Price Wetherill and Robert Bridges, M.D.; *Corresponding Secretary*, John Cassin.

OBITUARY.

John James Audubon died on the 27th of January, 1851, aged seventy-six years, at his residence on the banks of the Hudson. Audubon was born in Louisiana, and was the son of an admiral in the French navy. In his sixteenth year, he went to France for his education, and was there instructed in drawing by the celebrated David. In 1824 he became acquainted with Lucien Bonaparte, who suggested the publication of his drawings of birds already very numerous. This took him to Europe, and after a while his splendid work on the Birds of America was in progress. After his return to this country, he was off on new explorations, and visited the Floridas, Maine, Canadas, Labrador, and other regions. In 1842 he commenced the publication of the Quadrupeds of America, a work of unsurpassed magnificence, in which he was aided by Dr. Bachman.

Prof. H. C. Schumacher, the astronomer of Altona, and the distinguished editor of the *Astronomische Nachrichten*, died Dec. 28, 1850, in the 71st year of his age. His long and industrious life has been successfully devoted to the advancement of astronomy and the allied sciences.

VI. Bibliography.

1. *Patent Office Report, for* 1849. Part I, Arts and Manufactures, 624 pp., 8vo, with plates, Washington, 1850; Thos. Ewbank, Esq., Commissioner of Patents.—From this valuable document, we learn that the number of patents applied for in 1849 was 1955; of patents issued

during the year, 1076; of rejected and suspended applications (part from preceding year) 1409. About 750 patents expired during the year. The amount remaining in the Treasury to the credit of the Patent Fund, January 1st, 1850, was $169,505, and during the year $50,000 had been drawn out for the erection of wings to the building. This volume is illustrated by a series of 9 plates, affording a beautiful example of Chromo-lithography from the press of P. S. Duval, Philadelphia. There are six plates of the organs of motion of water-animals in illustration of a valuable paper by the Commissioner on the forms of paddles and propulsion of steamers. There is much good sense in the remarks on a household branch of patents, (*Atmospheric Churns*,) reported by Prof. C. G. Page, which we here cite.

The subject of churns belongs to the class of agriculture, which class will be reported upon by the Examiner having that branch in charge. In consequence of an unequal apportionment in the number of cases, I have had during the year forty-nine applications transferred to my desk, and among them twenty-one applications for churns. Most of these were styled atmospheric churns, and since I have been in the Patent Office I have never witnessed such a *mania* upon any one invention. The first impulse seems to have been given by the grant of a patent for a churn in which there were boxes upon opposite sides of a common revolving dasher, so situated that as the dasher revolved, the box containing the cream, with its open mouth downwards, carried down a portion of air to the bottom of the churn and as the mouth of the box inclined upwards, the air escaped from it through the mass of the cream, while the box itself filled with the cream, and as it came out and revolved in the upper part of the churn above the cream, that contained in the box was thrown out and scattered into spray. Both the descent and size of the box occasioned a commingling of the air and cream, and answered the purpose of agitation as well perhaps as any form of dasher. In the report of last year the rationale of atmospheric churns was given. It may be well to repeat that the introduction of air plays no chemical part in the production of butter, its separation from cream being merely a mechanical process. And although the atmospheric churns operate to a considerable advantage, yet it is by means of more thorough agitation, which is increased greatly by the diffusion of air throughout the cream. As each portion of air rises through the cream, it forms a bubble upon the surface before it escapes, and in some of the atmospheric churns, where the dasher is constantly submerged, the whole mass of cream is converted into a complete mass of foam. From the success of such a churn as that above named in producing butter in a shorter time than other churns, a most enthusiastic speculation was at once commenced upon atmospheric churns, and inventive powers were racked to modify, mystify and contort a simple principle, with a view of producing novelties rather than improvements. From the immense number of churns used throughout the country, great gains could not fail to follow the monopoly of a new and superior churn. The golden prospects have tempted many into the field, and it is quite curious to observe in this instance the natural drift of intellect, bringing the workings of independent minds into one common channel. A patent was granted for one species of atmos-

pheric churn, but before this could have been known far beyond the walls of the Patent Office, two other inventors, each and all from different parts of the country, had laid claim to the identical improvement. One was from Ohio, the second from Illinois, and the third from Vermont. An interference was accordingly declared, and no sooner had the decision been made in favor of the patentee, than three other inventors were found pressing their claims to the same invention. It presents an unprecedented case in the history of the Patent Office of seven persons, each a *bona fide* inventor, all claiming the same thing and about the same time, and all from distant portions of the country. This improvement consists simply in boring a hole through the entire length of a common upright churn dasher, and placing a valve either at the bottom or top of the dasher. This valve opens downwards, and when the dasher is raised with such rapidity that the cream cannot follow up, the air rushes down through the valve under the dasher, and upon the downward stroke the air is passed out laterally and escapes by the side of the dasher and up through the mass of cream. It requires not a very quick motion and but little force to effect this, and the agitation is most complete. A full sized model was exhibited in the office showing the operation with clear water only. Upon agitating the dasher, the water appeared as if in intense ebullition. Another peculiarity belongs to this churn worthy of note. In the common churn, the dasher has to be raised out of the cream at each stroke and plunged down with some force, and as this scatters the cream, it is necessary to cover the churn tightly and allow the dasher to play through a small hole in the centre of the cover; but in this atmospheric churn the dasher is kept always under the surface of the liquid, and consequently there is no splashing of the cream, and the cover may be left off with safety, and enable you to watch the operation. A strong recommendation is its simplicity, and as one of the inventors stated he could alter any common churn dasher to this principle for twenty-five cents.

Prior to this simple device for introducing air, several complicated inventions had been patented, and many more made and presented to the office to effect the same purpose. In truth this invention at first was not considered patentable; but after the exhibition of its actual operation by one of the inventors, a different view was adopted and a patent ordered to issue. As atmospheric churns were not new, the ground was taken that the use of any known means of introducing air was not patentable. The ground of action is correct in itself, but did not appear applicable in the case after a personal explanation from the inventor, and an exhibition of the operation and result of his invention. The patentability of an invention frequently turns upon a nice point, and inventions the most novel are sometimes the most worthless, while again others least novel in appearance, bearing the similitude of common and unpatentable devices, are most valuable and important in practice. Simplicity is the essence of true invention, and it is often interesting to see after a multitude of complicated inventions to attain a certain end, some discerning, or perhaps fortunate inventor, demolish a whole labyrinth of combinations, and arrive at the result by means so simple as almost to rob invention of its charms. Such means as one would suppose should have been the first and not the last resort. Mingled with

the surprise are often times feelings of regret and chagrin by his competitors, that they had not discovered this most obvious path. To such cases the words of Milton are quite apropos:

> "The invention all admired, and each how he
> To be the inventor missed; so easy it seemed,
> Once found, which yet unfound, most would have deemed
> Impossible!"

Such cases are the most embarrassing to your examiners. If measured by the length and breadth of novelty, little is to be found, while yet the measure of utility has in no way been made to appear. But to return to the churns.

A modification of the last named churn has been patented, in which the hole in the dasher at the lower part was large enough to contain a solid plunger, fitting loosely within the dasher, which acts the part of a second valve. There have been also several patents granted for ingenious forms of rotary atmospheric churns. These inventions crowded upon the office so numerously, that they were examined with the most rigid scrutiny, and on several occasions, actual demonstrations by experiment of making butter, was required of the applicants, to satisfy the office that the inventions claimed justified their pretensions to be real improvements. In most of these cases, the results were unfavorable to the inventor; but in some, patents were ordered to issue. On one occasion an experiment was performed (humorously characterized by a bystander as a "churn race,") between a patented and a new churn, in which they both came out alike, making butter from new milk in two minutes and a half. Such a rapid separation of the butter, however, is by no means desirable, although this is the general aim of these improvements. We have it upon the highest chemical authority, that butter made so rapidly is not likely to be as good as that which is made slowly.

2. *Pictorial Atlas of Fossil Remains*, consisting of Colored Illustrations selected from Parkinson's "Organic Remains of a Former World," and Artis's "Antediluvian Phytology;" with Descriptions by G. A. Mantell, Esq., LL.D., F.R.S., &c., xii, 208 pp. 4to, with 74 plates, containing nearly 900 figures. London. 1850. H. G. Bohn.—This elegant work, while embracing a large part of what gave value to the volume of Parkinson, has a much higher character and importance, and is more available to the geologist. The excellent plates of Parkinson, the last of which appeared just forty years since in what may be styled the infancy of geology, are accompanied with the modern scientific names of the species, and descriptive remarks. In this part of the labor of preparation, Dr. Mantell acknowledges the assistance of J. Morris, Esq., F.G.S., distinguished in the department of Palæontology. The frontispiece to the volume is a beautiful plate of the foot of the famous giant bird of New Zealand, the Moa, the remains of which have been obtained in a state of remarkable perfection by Walter Mantell, Esq., of Wellington, N. Z., son of Dr. Mantell, as mentioned in former numbers of this Journal. The engraving is a superb specimen of lithography and exhibits well the structure of this part of the skeleton; it is taken from a recent memoir by Dr. Mantell on this wonderful bird. The introductory part of the volume contains

an account of the colossal New Zealand birds. The volume closes with "Supplementary Notes" by Dr. Mantell, which add greatly to the interest of the volume. They embrace observations on The Fossil Bears of Caverns ;—The Structure of the Belemnite and Belemnoteuthis ;—The New Zealand Fossil birds ;—Botanical Arrangment of Fossil Vegetables ;—Fossil Cephalopoda, Nautilus, Ammonite, &c. ;—The Carboniferous Deposits or Coal Measures ;—Structure of Mineral Coal ;—On Fossil Corals ;—Cuvier's Discoveries at Montmartre ;—Fossil Edentata ; Animal Remains in Flint and other siliceous nodules ;—On Foraminifera ;—Fossil Elk of Ireland ;—Fossil Infusoria and Infusorial Earths ; —The Mosasaurus ;—Fossil Reptiles of the Wealden ;—Silicification or Petrifaction by flint ;—On Stigmaria, Sigillaria, with figures, illustrating the stumps and roots.

3. *On the Pelorosaurus, an undescribed Terrestrial Reptile* whose remains are associated with those of the Iguanodon and other Saurians in the strata of Tilgate Forest, in Sussex ; by G. A. MANTELL, Esq., F.R.S., &c. From the Philosophical Transactions. Part II, for 1850. London : 1850.

Supplementary Observations on the structure of the Belemnite and Belemnoteuthis ; by G. A. MANTELL, Esq., F.R.S. From the Phil. Trans., Part II, 1850. London : 1850.

The memoirs, whose titles are here given, have appeared within the past year, in the Philosophical Transactions. As an abstract has already been given in this Journal* a farther notice is not necessary. The illustrations are in the best style of lithography especially those of the various bones of the Pelorosaurus, whose forms are brought out with a clearness of detail and a boldness of tint that exhibits the hand of an artist.

The Dorsal dermal spine of the Hylæosaurus, recently discovered in the strata of Tilgate Forest, is the title of another memoir by Dr. Mantell in the Philosophical Transactions for 1850. On an examination, microscopally, in 1848, of sections of the spine, the internal structure was shown to be identical with that of the dermal scutes of the Hylæosaurus, presenting "long, straight, spicular fibres, decussating each other in all directions and representing as it seems the ossified ligamentous fibre of the original corium." Recently (in 1850) a specimen has been obtained in the Tilgate Forest, by Dr. Mantell exhibiting the proximal end or base of the spine and showing the nature of its connection with the animal and proving that his conclusion was right with regard to the nature of the spine. If perfect, the length would be 15 inches. The parts show that while in existing lizards the dermal appendages are flexible and cartilaginous, in certain fossil reptiles they are rigid osseous spines.

4. *A Treatise on Trigonometry, Plane and Spherical, with its application to Navigation and Surveying, Nautical and Practical Astronomy and Geography, with Logarithmic, Trigonometrical and Nautical Tables, for the use of Schools and Colleges.* A new edition with extensive additions and improvements ; by Rev. CHARLES W. HACKLEY, S.T.D., Prof. Math. and Astr. in Columbia College. 8vo. 372 pp. text and 238 of mathematical tables. New York. 1851. G. P. Putnam.—The author

* Vol. ix, 2nd ser., pp. 438, 439.

has prepared a convenient and thorough treatise on trigonometry in its various departments. While it is full in the exposition of principles and formulas, it is unusually complete in its account of mathematical and astronomical instruments, and in practical information respecting the various applications of Trigonometry, as in Surveying, Navigation, Geodesy and Nautical Astronomy. He has happily digested into a short systematic treatise the principal operations employed upon the coast survey of the United States, and has explained the use of the magnetic clock in recording observations, and entered into the subjects of canal and railroad engineering, and the construction of maps. The work is therefore well fitted for the practical surveyor and navigator, as well as for the scientific student; and it is made convenient for the nautical man by tables of logarithms, a traverse table, table of meridional parts, and others, which are mostly printed from the plates of Bowditch's Navigator, by permission of G. W. Blunt the proprietor of that work. The author has also introduced Prof. Chauvenet's paper on unlimited triangles, and has given a new method of deducing Napier's analogies by means of the Gauss equations.

5. *Review of Chemistry for Students*, adapted to the courses as taught in the principal Medical schools of the United States; by J. G. Murphy, M.D. 328 pp. 12mo. Philadelphia: 1851. Lindsay & Blakiston.—The author has prepared this work in order to furnish the student with a condensed review of the principles and facts of chemistry that may be a convenient accompaniment to a course of lectures, and serve for an easy revision of the subject. Although not offered as a text-book it has the same range in a briefer way. We are not satisfied with the illustration of repulsion, by a Prince Rupert's drop, and see a want of precision in some of the definitions. But the work is still a good one, and may well answer the purpose for which it is intended. The changes in the formation of compounds by complex decompositions are exhibited to the eye, and the facts under each head are systematically and clearly brought out.

6. *The advantages of a Geological Survey of the State of Missouri;* by H. A. Prout, M.D. 30 pp. 8vo. St. Louis. 1851.—The state of Missouri, although noted for its mineral wealth, is still unexplored by the geologist. Dr. Prout in this pamphlet has set forward the various advantages of an immediate survey, in a clear and striking light, and we add our endorsement to all he has said, and our earnest hope that the state may go forward in a work economically so profitable, and at the same time so honorable to her intelligence and love of science. It is a fact of some meaning, that in recent discourses upon the half century just ended, the progress of science has been the great theme. If science has carried forward the world with a progress so wonderful, a nation is not wasting money in the contributions that may be made toward any of its departments. Missouri has her mines of lead, copper, zinc, cobalt, iron; material for glass and porcelain; sources of salt, alum, copperas; and what other undeveloped treasures we know not. But even without such inducements to survey thoroughly her borders and obtain a just knowledge of her resources, the advancement of science in its highest and purest signification, should be a sufficient incentive.

7. *Reports on the Geology and Topography of California;* communicated to the Senate by the Secretary of War. Ex. Doc., No. 47, 31st Congress, 1st Session.—This volume includes a Report on California by Mr. P. T. Tyson; a Report of General Smith; of Lieut. Talbot to General Smith; of Prof. J. F. Frazer on minerals forwarded by Gen. Smith; of Gen. Riley; of Lieut. Ord to Gen. Riley; of Lieut. Derby of his survey of a portion of the valley of the Sacramento; of Lieut. R. S. Williamson of the reconnaissance made by Capt. W. H. Warner of a route through the Sierra Nevada by the Upper Sacramento. Mr. Tyson's Report occupies the larger part of the volume and contains much valuable information. In the Report of Lieut. Derby, the height of the Sacramento Bute* is given as follows: for the north peak 2,843 feet above the plain; for the south 1,841 feet.

Prof. Frazer gives the following analysis of the lignite of the Cowlitz, Oregon; sp. gr. 1·314.

Loss of weight at 212° (water &c.),	4·9
" " at red heat (bitumen),	49·5
" " by combustion (from carbon),	42·9
Ash residuum,	2·7
	100·0

A drab colored compact limestone, (sp. gr. 2·63,) from Monte Diavolo near San Francisco afforded Mr. A. Muckle his assistant,

Carbonate of lime,	97·8
Carbonate of magnesia,	*trace*
Oxyd of iron and alumina,	1·4
Silica,	0·3
Water,	0·25
	99·75

8. *Note Géologique sur les Terrains de Sabero, et de les Environs dans les Montagnes de Leon* (Espagne); par D. Casiano de Prado, Ingenieur des Mines, suivie d'une description des Fossiles de ces terrains, par M. Ed. de Verneuil. (From the Bulletin of the Soc. Geol. of France, 2nd Ser., vii, 137. Jan. 21, 1850.)—This memoir treats mainly of the coal-bearing rocks of the district of Sabero, Spain, which, although like the true carboniferous formation, de Verneuil is inclined to refer to the upper devonian. These beds extend over the region occupied by the villages of Sabero, Saelices, Olleros, Sotillo, Llama and Veneros, on both banks of the Esla, and are prolonged towards Colle and Las Bodas where they pass beneath Cretaceous rocks. The direction of the beds is in the main from east to west, and the inclination when not vertical is towards the south with slopes of 45 to 70°. Verneuil observes that whatever difference of opinion may exist as to the coal of Sabero, and also that of Ferrones and of Arnao (Asturias), there can be but one opinion about the limestones which accompany it; they are the same limestones with those of Viré, Izé, Gahard near Rennes, the harbor of Brest, and of Nehou (Manche) and of Ferques in France, and belong, as the fossils indicate, to the devonian formation. This important memoir is accompanied by figures and descriptions of the fossils by Verneuil.

* For a sketch of the Bute, see this Journal, 2nd Ser., vol. vii, p. 259.

9. *The Doctrine of the Unity of the Human Race examined on the Principles of Science*; by JOHN BACHMAN, D.D., Prof. Nat. Hist., Coll. of Charleston, S. C., &c. 312 pp. 8vo. Charleston: 1850.—It is of much interest to science that Dr. Bachman has entered the field on this important question. His known scientific learning, a result of extended personal observation as well as thorough study, will give weight to his opinions and confidence to his statements. He brings a large amount of facts to sustain the doctrine of the unity of the human race in its strictest sense.

We must still acknowledge that this subject has but just begun to be investigated; and we hail with pleasure all contributions relating to it, from whatever direction and whatever their bearing. The result ultimately established will be truth: and any restlessness or ill temper shown in the progress of the debate will prove only an exhibition of weakness or cowardice. Facts alone, carefully studied, and pursued in all their ramifications, are the proper means of combating error, and these should be thrown into the general fund with that exalted trust in the divine origin of truth which subdues all personal feeling and ennobles both science and religion. The latter has nothing to lose, and both have much to gain from honest, sober investigation.

10. *Contributions to Conchology*, No. 8, pp. 125—152; by Prof. C. B. ADAMS.—This number of Prof. Adams's Contributions contains descriptions of new species of Partula, and Achatinella (Sandwich Islands); and of Marginella, Buccinum, Valvata, Planorbis, Ancylus, Truncatella, Helicina, Cyclostoma and Stoastoma from Jamaica.

11. *The Western Agriculturalist*, A Monthly Journal devoted to Agriculture, Political Economy, Arts and Manufactures, &c., Edited by W. W. MATHER, Corresponding Secretary of the Ohio State Board of Agriculture. Vol. I, No. I, January, 1851, 32 pp. large 8vo, Columbus, Ohio.—It is a high recommendation of the Western Agriculturalist, that it has the editorial labors of Prof. Mather, so well known for his able geological researches. Prof. Mather's qualifications are not merely scientific; for, as he observes, during the last ten years he has been a practical farmer in Ohio, and cleared the land for a home in a forest that the axe had not touched. The Board of Agriculture of Ohio, unsolicited, appointed Prof. Mather to the office of Corresponding Secretary of the Board and Agricultural Chemist of the state, and by urgent request, he has consented to edit an agricultural Journal. The numbers will present the recent developments of science in their bearing on agriculture, and also whatever of a practical character can be of avail in the household, the dairy, on the farm, or in the workshop. Domestic economy and domestic manufactures will receive attention as well as agriculture and its associated departments.

12. *Boston Journal of Natural History.* Vol. VI, No. 2. 296 pp. 8vo., with 4 plates.

I. ASA GRAY: Plantæ Lindheimerianæ. Part II. An account of a collection of plants made by F. Lindheimer in Texas in the years 1845–6 and 1847–8. pp. 141—240.

II. W. O. AYRES: Description of a new species of Polypterus, from West Africa; with a plate. The species is called P. palmas, from Cape Palmas, its locality. pp. 241—246.

III. Horatio R. Storer: Observations on the Fishes of Nova Scotia and Labrador, with descriptions of new species. pp. 247—270, illustrated by plates.*

IV. N. M. Hentz: Descriptions and figures of the Araneides of the United States, (concluded.) pp. 271—295.

C. T. Jackson, M.D.: An address delivered before the Plymouth County Agricultural Society, at their Annual Exhibition in the Town of Bridgewater. 30 pp. 8vo. *Boston.* 1850.

Prof. J. Brocklesby: Views of the Microscopic World: designed for general reading and as a hand-book for classes in natural science. 146 pp. 16mo, illustrated with numerous engravings. *New York*, 1851. Pratt, Woodford & Co.

R. Hunt Snelling: The Photographic Art Journal, a monthly periodical; vol. i, No. 1. January, 1851. *New York.*

Smithsonian Contributions to Knowledge: Occultations visible in the United States during the year 1851, computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a Nautical Almanac. 26 pp. 4to. *Washington*, 1850.

Smithsonian Contributions to Knowledge: Ephemeris of the Planet Neptune, for the year 1851; by Sears C. Walker. 10 pp. 4to. *Washington*, 1850.

Smithsonian Contributions to Knowledge: Researches relative to the Planet Neptune; by Sears C. Walker, dated Washington, April 10, 1848, 60 pp. 4to.—The memoir treats of (I) Abstract of Events connected with the discovery of Neptune, the Progress made in its Theory and the completion of the Theory of Uranus; (II) Detailed account of the two ancient places of Neptune, observed by Lalande in May, 1795; (III) Computations confirming the authenticity of Lalande's Printed observations; (IV) Subsequent Researches on the Orbit of Neptune.

Smithsonian Contributions to Knowledge: Aboriginal Monuments of the State of New York; by E. G. Squier, A.M. 188 pp. 4to, with 14 plates. 1851.

Smithsonian Institution: Fourth Annual Report of the Board of Regents of the Smithsonian Institution, for the year 1849. 64 pp. 8vo. *Washington*, 1850. Senate Document Misc. No. 120. 31st Congress, 1st Session.

Abbildungen u. Beschreibungen neuer u. seltener Thiere u. Pflanzen in Syrien u. im westl. Taurus gesammelt v. Th. Kotschy, herausg. v. den D. D. Fenzl, Heckel und Redtenbacher, 2 Lfg. Imp. 4to, (25 lithog., 107—1058 pp. of text in large 8vo.) *Stuttgart.* 1849. 2⅔ *dollars.*

F. Becker: Geognostische Skizze von Hessen. 66 pp. large 8vo. *Darmstadt*, 1849. ⅓ *dollar.*

Beiträge zur Pflanzenkunde des Russischen Reiches. Hrsg. v. der Kaiserl. Acad. der Wissenschaften. 6 Lfg. large 8vo, 62 pp. *St. Petersburg*, 1849. *Leipzig*, Voss.

Dr. A. Blattmann: Mikroskopisch-anat. Darstellung der Central-organe d. Nervensystems bei den Batrachiern m. besond. Berüchsicht. von Rana esculenta. Large 8vo, 95 pp. and 1 lithog. in 4to. *Zurich.*

Prof. Dr. H. Burmeister: Die Labyrinthodonten aus dem bunten Sandstein v. Bernburg, zoologisch geschildert 1 Abth; Trematosaurus, iv and 71 pp. with 4 lithog. in 4to. Berlin, 1849. G. Reimer. 3⅓ *dollars.*

Dr. W. Ebel: Geographische Naturkunde od. Grundzüge einer algem. Naturgeschichte der drei Reiche m. physiognom. Schilderung der Erdoberfläche f. Studirende, Schulmänner u. Gebildete überhaupt, 1 Abth. Plan der Geog. Nat., 2 Abth.; Geog. Nat. v. Island, xvi and 446 pp. 8vo, with 14 lithog. *Königsberg.*

Dr. H. W. Dove: Monats-isothermen. 32 pp. 4to, with 3 lith. *Berlin*, 1849. D. Reimer, 2⅓ *dol.*

Dr. E. Harless: Ueber d. Zahnbau v. Myliobates. 36 pp. 4to, with 3 lithog. Munich. From the Transactions of the Bavarian Academy.

J. J. Heckel: Abbildungen u. Beschreib. neuer Thiere. Beiträge zur Kentniss der foss. Fische Oesterreichs, Abh. I, Chirocentrites, Pimelodus, Saurorhamphus, Amphisyle, Meletta, Clupea, Lepidopides, Lepidotus. Fol. 44, pp. with an Atlas of 15 lithog. *Vienna*, 1849.

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* The new species described are mentioned on p. 129 of this volume.

Dr. G. A. W. Herrich-Schäffer: Schmetterlinge v. Europa. Revision u. Supplemente zu J. Hübner's Sammlung europ. Schmetterlinge. 41 and 42 parts. Large 4to. 48 pp. of text, and 20 colored lithog. *Regensberg.* $3\frac{1}{6}$ *dol.*

Dr. Martius: De Genera et species Plantarum etc. Fasc. ix. 256 pp. imp. fol. and 26 lithog. 1849. Uncol. 34 *dol.*; col. $45\frac{2}{3}$ *dol.*, for fasc. i—ix uncol., 182 *dol.*, col. $314\frac{2}{3}$ *dol.*

Dr. A. Th. v. Middendorff: Malacozoologia Rossica. Abth. ii and iii, 281 pp. 4to, with 21 lithog. *St. Petersburg.* 1849. *Leipzig*, Voss.

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J. H. C. F. Sturm: On Leptodirus, genus of the family of Scydmænides. 8 pp. 8vo, with 1 col. plate. *Nuremberg*, 1849. $\frac{1}{2}$ *dol.*

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Zeitschrift der deutschen geologischen Gesellschaft, 2nd vol. 4th part. Large 8vo, 64 pp. with lithog. *Berlin.* 6 *dol.*

Dr. Albert Wigand: Intercellularsubstanz und Cuticula,—a Treatise on the structure and metamorphosis of vegetable cell membrane. vi and 130 pp. 8vo, with 2 plates. *Braunschweig*, 1850. $1\frac{1}{2}$ *dol.*

G. Ritschl: Flora des Grossherzogthums Posen, im Auftrage des naturhist. Vereins zu Posen. xxxii and 291 pp. 8vo. *Berlin*, 1850. $1\frac{1}{3}$ *dol.*

Proceedings of Bost. Soc. Nat. Hist.—1850.—p. 305, On certain species of Pike; *Z. Thompson.*—p. 307, Snowfly and Larves; *J. S. Davis.*—p. 309, New species of U.S. Exploring Expedition Shells (Genera Avicula, Crenatula, Perna); *A. A. Gould.*—p. 312, On Cottus variabilis as distinct from C. Groenlandicus; *Mr. Ayres.*—On Ibis guarauna in New England; *Dr. Cabot. July.*—p. 319, Remarks on Naviculæ: *Dr. Burnett. August.*—p. 321, Red oxyd of Zinc and Franklinite of New Jersey; *C. T. Jackson.*—323, A bullfrog found with a mouse in his stomach, and others feeding on spiders.—p. 324, Pot holes in New Hampshire; *C. T. Jackson.*—p. 324, Relations of the order of Parasites (Lice) to different Faunæ; *Dr. Burnett. September.*—p. 328, Observations on bones of the Zeuglodon; *Dr. Wyman. October.*—p. 332, Two new species of Philine; *Mr. Stimpson.*—p. 335, Tumor from an Ixodes; *Dr. J. M. Warren.*—p. 335, Remarks on the age of the Sandstones of the Connecticut river and Lake Superior Regions, &c.; *C. T. Jackson.*—p. 336, Ibid; *Prof. Agassiz.*

Proceedings of the Acad. Nat. Sci. Philadelphia, Vol. V. *August.*—p. 66, Fossil Mammalia from Missouri; *D. D. Owen* and *J. G. Norwood.*—p. 67, New birds of the genera Paradisea, Pastor and Buceros; *J. Cassin. September.*—p. 81, On the word species; *Dr. Morton.** *October.*—p. 85, On the antiquity of some Races of Dogs; *Dr. Horton.*—p. 90, On two new Mammalian Fossils; *J. Leidy.*†—Meteorological Table from Chagres to New York; *R. C. Taylor.*—p. 96, Contributions to Helminthology; *J. Leidy.*†—p. 98, On the development of the Gordius aquaticus; *J. Leidy.*†—p. 100, Two new species of Infusorial Entozoa; *J. Leidy.*† —p. 100, On some Nematoid Entozoa: *J. Leidy.*—p. 103, Descriptions of some new birds of the Genera Parus, Emberiza, Carduelis, Myiothera and Leuconerpes in the Collections of the Academy; *J. Cassin. November.*—p. 107, Descriptions of three Filariæ; *J. Leidy.*† *December.*—p. 119, On the nettling organs of the Hydra; *J. Leidy.*—p. 121, On some species of Fossil Mammalia; *J. Leidy.*†—p. 122, On embalmed heads of Egypt; *Dr. Morton.*—p. 124, New Genera and Species of Vermes; *J. Leidy.*—p. 126, On a new American Duck; *J. Cassin.*

Proceedings American Phil. Soc. Philadelphia. Vol. V, No. 45. *May.* 1850.—Effects of the gold mines of California on the currency; *Prof. Tucker.*—Gold from near Bloomington, Indiana; *Prof. Frazer. September.*—p. 159, Letter from Dr. Kane, of the Arctic Expedition in search of Sir John Franklin. *December.*—p. 170, Remark on the Washington Half-dollar; *Mr. Justice.*

Annales des Sciences Naturelles, 3d ser., vol. xiii. MARCH, 1850.—Melastomaceæ in the Paris Museum; *C. Maudin.*—Researches on the Colors of Vegetation; *M. F. S. Morot.*—On the artificial fecundation of the eggs "de Hermelle et de Taret;" *A de Quatrefages.*—On the Metamorphoses of the Asili; *L. Dufour.*—On the formation of Muscles in the Vertebrata and on the structure of muscular fibre in different classes of animals (2nd Memoir); *Dr. Lebert.*

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* See this volume, p. 275.

† Ib. p. 274.

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ERRATUM.

P. 97, 9th l. from bottom, for *Lagostoma nodosa*, read *Lagostoma perlatus*.

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THE

AMERICAN JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXIII.—*On the Aboriginal Monuments and Relics of New York;* by E. G. Squier, A.M.*

GENERAL OBSERVATIONS ON THE ABORIGINAL MONUMENTS OF THE STATE OF NEW YORK.†

The Indian tribes found in possession of the country now embraced within the limits of New England and the Middle States have left few monuments to attest their former presence. The fragile structures which they erected for protection and defense have long ago crumbled to the earth; and the sites of their ancient towns and villages are indicated only by the ashes of their long-extinguished fires, and by the few rude relics which

* We cite here a few pages from a work by Mr. Squier, just published by the Smithsonian Institution, entitled, Aboriginal Monuments of the State of New York, comprising the results of original surveys and explorations, (188 pp. 4to, with 14 plates and numerous wood-cuts.) The researches in New York were undertaken in 1848, under the joint auspices of the Smithsonian Institution and the Historical Society of New York, and the work contains the results arrived at. The various monuments of the several counties of the state are described with detail, as far as known, their uses and history described, and other topics bearing upon the customs of their builders are treated of with much learning and discrimination. An Appendix contains general conclusions with regard to the Indians and their works, drawn from the various investigations which have been made over the continent. In our citations from the work, we pass by a large amount of detail of great interest well illustrated by the plates and sketches, and give but a partial view of the various results brought out in the work—referring the reader to the work itself for a complete account of the author's observations and deductions. Many points are illustrated with fullness and beauty in Mr. Squier's earlier work on "the Ancient Monuments of the Mississippi Valley," published in 1848, as the first volume of the Smithsonian Contributions to Knowledge in a 4to volume of 300 pages.

† Pages 9–13.

the plough of the invader exposes to his curious gaze. Their cemeteries, marked in very rare instances by enduring monuments, are now undistinguishable, except where the hand of modern improvement encroaches upon the sanctity of the grave. The forest-trees, upon the smooth bark of which the Indian hunter commemorated his exploits in war, or success in the chase —the first rude efforts towards a written language—have withered in the lapse of time, or fallen beneath the inexorable axe. The rock upon which the same primitive historian laboriously wrought out his rude but to him significant picture, alone resists the corrosion of years. Perhaps no people equally numerous have passed away without leaving more decided memorials of their former existence. Excepting the significant names of their sonorous language, which still attach to our mountains, lakes, and streams, little remains to recall the memory of the departed race.

But notwithstanding the almost entire absence of monuments of art clearly referable to the Indian tribes discovered in the actual possession of the region above indicated, it has long been known that many evidences of ancient labor and skill are to be found in the western parts of New York and Pennsylvania, upon the upper tributaries of the Ohio, and along the shores of Lakes Erie and Ontario. Here we find a series of ancient earth-works, entrenched hills, and occasional mounds or tumuli, concerning which history is mute, and the origin of which has been regarded as involved in impenetrable mystery. These remains became a subject of frequent remark, as the tide of emigration flowed westward; and from time to time, various detached notices of their existence were made public. No connected view, however, of their extent or character was given to the world, until 1817, when De Witt Clinton, whose energetic mind neglected no department of inquiry, read a brief memoir upon the subject before the "Literary and Philosophical Society of New York," which was published in pamphlet form, at Albany, in 1818. Mr. Clinton in this memoir did not profess to give a complete view of the matter; his aim being, in his own language, "to awaken the public mind to a subject of great importance, before the means of investigation were entirely lost." It consequently contains but little more than notices of such ancient earth-works, and other interesting remains of antiquity, as had at that time fallen under his notice, or of which he had received some distinct information. Its publication, however, was without any immediate effect; for few individuals, at that period, felt the interest requisite, or possessed the opportunities necessary, for the continuance of the investigations thus worthily commenced. Nothing further, it is believed, appeared upon the subject, until the publication of McCauley's History of New York, in 1828. This

work contained a chapter upon the antiquities of the state, embodying the essential parts of Mr. Clinton's memoir, together with some facts of considerable interest, which had fallen under the observation of the author himself. Within a few years, public attention has again been directed to the subject by Mr. Schoolcraft, in his "Notes on the Iroquois." Some detached facts have also been presented in local histories and publications, but usually in so loose and vague a manner as to be of little value for purposes of comparison and research.

The observations of all these authorities were merely incidental, and were limited in their range. By none were presented plans from actual surveys of any of the ancient works of the state; a deficiency which, it is evident, could not be supplied by descriptions, however full and accurate, and without which it has been found impossible to institute the comparisons requisite to correct conclusions as to the date, origin, and probable connections of these remains. It has all along been represented that some of the enclosures were of regular outlines, true circles and ellipses and accurate squares—features which would imply a common origin with the vast system of ancient earth-works of the Mississippi valley. Submitted to the test of actual survey, I have found that the works which were esteemed entirely regular are the very reverse, and that the builders, instead of constructing them upon geometrical principles, regulated their forms entirely by the nature of the ground upon which they were built. And I may here mention, that none of the ancient works of this state, of which traces remain displaying any considerable degree of regularity, can lay claim to high antiquity. All of them may be referred with certainty to the period succeeding the commencement of European intercourse.

Mr. Clinton was unable to learn of the occurrence of any remains upon the first terrace back from the lakes, and, upon the basis of the assumed fact of their non-existence, advanced the opinion that the subsidence of the lakes and the formation of this terrace had taken place since these works were erected—a chronological period which I shall not attempt to measure by years. This deduction has been received, I believe, by every succeeding writer upon the subject of our antiquities, without any attempt to verify the assumption upon which it rests. I have, however, found that the works occur indiscriminately upon the first and upon the superior terraces, as also upon the islands of the lakes and rivers.

Misled by statements which no opportunity was afforded of verifying, I have elsewhere, though in a guarded manner, ventured the opinion that the ancient remains of western New York belonged to the same system with those of Ohio and the West generally. Under this hypothesis, the question whether they

were the weaker efforts of a colony, starting from the south-western centres, or the ruder beginnings of a people just emerging from a nomadic state, becoming fixed in their habits, and subsequently migrating southward, next suggested itself; and I gladly availed myself of the joint liberality of the Smithsonian Institution and the Historical Society of New York, to undertake its investigation. The results of my observations are briefly presented in the following pages. These observations extended from the county of St. Lawrence on the north, to Chautauque on the south, embracing the counties of Jefferson, Oswego, Onondaga, Oneida, Cayuga, Seneca, Ontario, Wayne, Monroe, Livingston, Orleans, Niagara, Erie, Genesee, and Wyoming. Throughout this entire region, ancient remains are found in considerable abundance; they are also occasionally found in the counties adjoining those above named, upon the principal tributaries of the Delaware, Susquehannah, and Alleghany. They are known to extend down the Susquehannah, as far as the valley of the Wyoming; and a single one was discovered as far east as Montgomery county, in the neighborhood of Fort Plain. Some, it is said, are found in Canada; but no definite information was received of their localities. It is to be observed that they are most numerous in sections remarkable for their fertility of soil, their proximity to favorable hunting and fishing grounds—in short, possessing the greatest number of requisites to easy subsistence. They are particularly numerous in Jefferson county, in the vicinity of the central lakes, in the southern part of Monroe, in Livingston, Genesee, and Erie counties. Many are said to exist in Chautauque; but the lateness of the season, and the unsuspected number of remains elsewhere claiming attention, prevented me from examining them.

In respect to the number of these remains, some estimate may be formed from the fact that, in Jefferson county alone, *fifteen* enclosures were found, sufficiently well preserved to admit of being traced throughout. This is exclusive of those (probably a greater number) which have been wholly or in part destroyed, or of which no information could be obtained, in the limited time allotted to the investigation of that county. It is safe to estimate the whole number which originally existed here at between thirty and forty—a greater number than was before known to exist in the state. Erie county probably contained nearly as many. In the short period of eight weeks devoted to the search, I was enabled to ascertain the localities of not less than one hundred ancient works, and to visit and make surveys of half that number. From the facts which have fallen under my notice, I feel warranted in estimating the number which originally existed in the state at from two hundred to two hundred and fifty. Probably one half of these have been obliterated by the plough, or so much encroached upon as to be no longer satisfactorily traced.

Were these works of the general large dimensions of those of the Western states, their numbers would be a just ground of astonishment. They are, however, for the most part, comparatively small, varying from one to four acres,—the largest not exceeding sixteen acres in area. The embankments, too, are slight, and the ditches shallow; the former seldom more than four feet in height, and the latter of corresponding proportions. The work most distinctly marked exists in the town of Oakfield, Genesee county; it measures, in some places, between seven and eight feet from the bottom of the ditch to the top of the wall. In some cases the embankment is not more than a foot in height, and the trench of the same depth. Lest it should be doubted whether works so slight can be satisfactorily traced, it may be observed, that a regular and continuous elevation of six inches may always be followed without difficulty.

In respect of position, a very great uniformity is to be observed throughout. Most occupy high and commanding sites near the bluff edges of the broad terraces by which the country rises from the level of the lakes. From the brows of the limestone ledges where some of these works occur, in Jefferson and Erie counties, most extensive prospects may be obtained, often terminating in the blue belt of the lakes, distant from ten to forty miles; the intervening country presenting a beautiful variety of cleared and forest lands, dotted with houses, churches, and villages. When found upon lower grounds, it is usually upon some dry knoll or little hill, or where banks of streams serve to lend security to the position. A few have been found upon slight elevations in the midst of swamps, where dense forests and almost impassable marshes protected them from discovery and attack. In nearly all cases they are placed in close proximity to some unfailing supply of water, near copious springs or running streams. Gateways, opening toward these, are always to be observed, and in some cases guarded passages are also visible. These circumstances, in connection with others not less unequivocal, indicate, with great precision, the purposes for which these structures were erected.

It has already been mentioned that Messrs. Clinton, Yates, and Moulton, and others, have concluded, upon the assumption that none of these works occur upon the first and second terraces above the lakes, that the latter have subsided to the present level since their erection. This conclusion does not necessarily follow from the premises. Few positions susceptible of defense, under the system practised by all rude people, are to be found upon either of these terraces; the builders, consequently, availed themselves of the numerous headlands and other defensible positions which border the supposed ancient shores of the lakes, simply because they afforded the most effectual protection, with the least expenditure of labor.

I found an entire uniformity in the indications of occupancy, and in the character of the remains of art discovered within these enclosures, throughout the whole range of their occurrence. The first feature which attracts notice, upon entering them, is a number of pits or excavations in the earth, usually at the points which are most elevated and dry. These pits are occasionally of considerable size, and are popularly called "wells," although nothing is more obvious than that they never could have been designed for any such purpose. They are usually from three to four, but sometimes from six to eight feet in depth, and of proportionate size at the top. Their purposes become sufficiently evident upon excavation. They were the *caches* in which the former occupants of these works deposited their stores. Parched corn, now completely carbonized by long exposure, is to be discovered in considerable abundance in many of them. Instances fell under my notice where it had been found untouched to the amount of bushels, in these primitive depositories. Traces of the bark and thin slips of wood, by which the deposits were surrounded, are also frequently to be found. In many of these enclosures the sites of the ancient lodges, or cabins, are still to be traced. These are marked by considerable accumulations of decomposed and carbonaceous matter—stones much burned, charcoal and ashes mingled with the bones of animals, with numerous fragments of pottery, broken pipes, and occasionally rude ornaments, such as beads of stone, bone, and shell. The pottery, I may observe incidentally, is of very good material, and appears to have been worked and ornamented with considerable taste and skill. It is found in great abundance; and, in many of the enclosures now under cultivation, bushels of fragments might, if desirable, be collected without difficulty. The material, in common with that of all the aboriginal pottery of the North, is composed of clay tempered (if I may use the term) with pounded quartz and shells, or with fine sand, so as to prevent shrinkage, and resist the action of fire. Most of it is well burned, but none exhibits any appearance of glazing. The pipes are mostly composed of clay, regularly and often fancifully moulded, and ornamented in various ways. Some bear the form of animals, the distinctive features of which are well preserved; others are moulded in the shape of the human head, or are variously fluted and dotted with regular figures. They are generally of very good material, the clay of fine quality, and well burned. Some, indeed, are so hard, smooth, and symmetrical, as almost to induce doubts of their aboriginal origin. Some of the terra cottas, other than pipes, are really very creditable specimens of art, and compare favorably with any of the productions of the aborigines which have fallen under my notice. They are, with few exceptions, representations of animals; with the minutest features, as

well as the peculiar habits of which, the American Indians had, from long observation, a thorough acquaintance.

CONCLUDING OBSERVATIONS ON THE NEW YORK MOUNDS.*

By whom were the aboriginal monuments of Western New York erected, and to what era may they be ascribed? The consideration of these questions has given rise to a vast amount of speculation, generally not of the most philosophical, nor yet of the most profitable kind. If the results arrived at have been erroneous, unsatisfactory, or extravagant, it may be ascribed to the circumstance that the facts heretofore collected have been too few in number, and too poorly authenticated, to admit of correct conclusions, not less than to the influence of preconceived notions, and to that constant leaning towards the marvellous, which is a radical defect of many minds. Rigid criticism is especially indispensable in archæological investigations; yet there is no department of human research in which so wide a range has been given to conjecture. Men seem to have indulged the belief that here nothing is fixed, nothing certain, and have turned aside into this field as one where the severer rules which elsewhere regulate philosophical research are not enforced, and where every species of extravagance may be indulged in with impunity. I might adduce numberless illustrations of this remark. The Indian who wrought the rude outlines upon the rock at Dighton, little dreamed that his work would ultimately come to be regarded as affording indubitable evidence of Hebrew, Phœnician, and Scandinavian adventure and colonization in America; and the builders of the rude defences of Western New York, as little suspected that Celt and Tartar, and even the apochryphal Madoc with his "ten ships," would, in this the nineteenth century of our faith, be vigorously invoked to yield paternity to their labors!

The probable purposes to which these works were applied are perhaps sufficiently evident from what has already been presented. Their positions, general close proximity to water, and other circumstances not less conclusive, imply a defensive origin. The unequivocal traces of long occupancy found within many of them, would further imply that they were fortified towns and villages, and were permanently occupied. Some of the smaller ones, on the other hand, seem rather designed for temporary protection,—the citadel in which the builders sought safety for their old men, women, and children, in case of alarm or attack.

In respect to date, nothing positive can be affirmed. Many of them are now covered with heavy forests; a circumstance upon which too much importance has been laid, and which in itself

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* Pages 81–84.

may not necessarily be regarded as indicative of great age; for we may plausibly suppose that it was not essential to the purposes of the builders that the forests should be removed. Still I have seen trees from one to three feet in diameter standing upon the embankments and in the trenches; which would certainly carry back the date of their construction several hundred years, perhaps beyond the period of the discovery in the fifteenth century. There is nothing, however, in this circumstance, nor in any other bearing upon the subject, which would necessarily imply that they were built by tribes anterior to those found in occupation of the country by the whites. And this brings us at once to the most interesting point of our inquiry, viz.: *By whom were these works erected?*

I have already mentioned that within them are found many relics of art and many traces of occupancy. These, as I had ample opportunities of ascertaining in the course of my investigations, are absolutely *identical* with those which mark the sites of towns and forts known to have been occupied by the Indians, within the historical period. The pottery taken from these sites and from within the supposed ancient enclosures, is alike in all respects; the pipes and ornaments are undistinguishable: and the indications of aboriginal dwellings are precisely similar, and, so far as can be discovered, have equal claim to antiquity. Near many of these works are found cemeteries, in which well-preserved skeletons are contained, and which, except in the absence of remains of European art, differ in no essential respect from the cemeteries found in connection with the abandoned modern towns and "castles" of the Indians. There are other not less important facts and coincidences, all of which go to establish that if the earth-works of Western New York are of a remote ancient date, they were not only *secondarily* but *generally* occupied by the Iroquois or neighboring and contemporary nations; or else—and this hypothesis is most consistent and reasonable—they were erected by them.

The questions by whom were the aboriginal monuments of Western New York erected, and to what era may they be ascribed, have probably been answered to the satisfaction of every mind by the simple detail of facts in the preceeding chapters.

It may be objected that if the Indians constructed works of this kind, it could not have escaped the notice of the early explorers, and would have been made the subject of remark by them. The omission is singular, but not unaccountable. They all speak of the defences of the Indians as composed of palisades firmly set in the ground. The simple circumstance of the earth being heaped up around them, to lend them greater firmness, may have been regarded as so natural and simple an expedient, as not to be deserving of special mention, particularly as the em-

bankment, in such a case, would be an entirely subordinate part of the structure. After the introduction of European implements, enabling the Indians to plant their pickets more firmly in the ground, and to lend them a security before unattainable, the necessity for an embankment was in a great degree obviated. We may thus account for its absence in their later structures, which also underwent some modification of form, suggested by the example or instructions of the whites, or by the new mode of warfare following the introduction of fire-arms. Thus in the plan of the old Seneca fort of *Ganundasaga*, we find distinct traces of the bastion—a feature observable in none of the more ancient defences.

I am aware that the remnants of the Indian stock which still exist in this state, generally profess total ignorance of these works. I do not, however, attach much importance to this circumstance. When we consider the extreme likelihood of the forgetfulness of ancient practices, in the lapse of three hundred years, the lack of knowledge upon this point is the weakest of all negative evidence. Cusick, the Indian, in his so-called "History of the Six Nations," has, no doubt, correctly described the manner in which they constructed their early defences. "The manner of making a fort: First, they set fire against as many trees as it requires to make the enclosure, rubbing off the coals with their stone axes, so as to make them burn faster. When the tree falls, they put fires to it about three paces apart, and burn it into pieces. These pieces are then brought to the spot required, and set up around, according to the bigness of the fort. *The earth is then heaped on both sides.* The fort has generally two gates, one for passage and one to the water." "The people," continues Cusick, "had implements with which they made their bows and arrows. Their kettles were made of baked clay; their awls and needles of sharpened bones; their pipes of baked clay or soft stone; a small turtle-shell was used to peel the bark, and a small dry stick to make fire by boring it against seasoned wood."

Colden observes of their defences, as they were constructed in his time: "Their castles are generally a square surrounded with palisades, without any bastions or outworks; for, since the general peace, their villages all lie open."*

In full view of the facts before presented, I am driven to a conclusion little anticipated when I started upon my trip of exploration, that the earth-works of Western New York were erected by the Iroquois or their western neighbors, and do not possess an antiquity going very far back of the discovery. Their general occurrence upon a line parallel to and not far distant from the lakes, favors the hypothesis that they were built by frontier

* History of the Five Nations, vol. i, p. 9.

tribes—an hypothesis entirely conformable to aboriginal traditions. Here, according to these traditions, every foot of ground was contested between the Iroquois and the Gah-kwas and other western tribes; and here, as a consequence, where most exposed to attack, were permanent defences most necessary. It was not till after the Confederation, that the Five Nations were able to check and finally expel the warlike people which disputed with them the possession of the beautiful and fertile regions bordering the lakes; and it is not impossible that it was the pressure from this direction which led to that Confederation,—an anomaly in the history of the aborigines. Common danger, rather than a far-seeing policy, may be regarded as the impelling cause of the consolidation.

In conclusion, I may be permitted to observe, that the ancient remains of Western New York, except so far as they throw light upon the system of defence practised by the aboriginal inhabitants, and tend to show that they were to a degree fixed and agricultural in their habits, have slight bearing upon the grand ethnological and archæological questions involved in the ante-Columbian history of the continent. The resemblances which they bear to the defensive structures of other rude nations, in various parts of the world, are the result of natural causes, and cannot be taken to indicate either a close or remote connection or dependence. All primitive defences, being designed to resist common modes of attack, are essentially the same in their principles, and seldom differ much in their details. The aboriginal hunter and the semi-civilized Aztec, selected precisely similar positions for their fortresses, and defended them upon the same general plan; yet it would be palpably unsafe to found conclusions as to the relations of the respective builders, upon the narrow basis of these resemblances alone.

USE OF COPPER AND SILVER BY THE AMERICAN ABORIGINES.*

In the paragraphs relating to St. Lawrence county, mention is made of a singular aboriginal deposite of burial, on the Canadian shore of the St. Lawrence River, near Brockville. Here were found a number of skeletons and a variety of relics, among which were a number of copper implements. They were buried fourteen feet below the surface of the ground. Two of the copper articles were clearly designed as spear-heads; they were pointed, double-edged, and originally capable of some service. One was a foot in length. A couple of copper knives accompanied these, and also an implement which seems to have been designed as a gouge.† Some implements entirely corresponding with these have been found in Isle Royal, and at other places in and around

* Pages, 176–188. † Ancient Monuments of Mississippi Valley, p. 201.

Lake Superior. Whether or not these are relics of the existing Indian tribes, it is not undertaken to say, although it seems highly probable that they are. That the Indians of New England, New York, and Virginia, to a limited extent, possessed copper ornaments and implements at the time of the discovery, is undoubted; but it is not to be supposed for an instant that they obtained it by smelting from the ores. They unquestionably procured it from the now well known native deposits around Lake Superior.

Raleigh observed copper ornaments among the Indians on the coast of the Carolinas; and Verazzano mentions articles, probably ornamental, of wrought copper, among the natives which he visited in a higher latitude, "which were more esteemed than gold." Granville speaks of copper among the Indians of Virginia, which were said to have been obtained among the *Chawanooks* (Shawanoes?). "It was of the color of our copper, but softer." He endeavored to visit the place where it was represented to be found; but after a toilsome journey of some days into the interior, the search was abandoned. This was a grievous disappointment at that time, when the minds of men were filled with visions of vast mineral wealth, and when the value of the New World was thought to consist in its mines. Granville thus concludes his account of his fruitless expedition: "I have set down this voyage somewhat particularly, to the end that it may appear unto you (as true it is) that there wanted no good will, from the first to the last of us, to have perfected the discovery of this mine; for that the discovery of a good mine, by the goodness of God, or a passage to the South Sea, or some way to it, and nothing else, can bring our country in request to be inhabited by our people."* Heriot says, "In two towns 150 miles from the main, are found divers small plates of copper, that are made, we are told by the inhabitants, by people who dwell farther in the country, where, they say, are mountains and rivers which yield white grains of metal, which are deemed to be silver. For the confirmation whereof, at the time of our first arrival in the country, I saw two small pieces of silver, grossly beaten, about the weight of a *tester*, [an old coin about the weight of a sixpence sterling.] hanging in the ears of a Wiroance. The aforesaid copper we found to contain silver."† Robert Juet, in his account of Hudson's discovery of the river which bears his name, asserts that the savages "had red copper tobacco pipes, and other things of copper, which they did wear about their necks." He makes mention, in another place, of "yellow copper," as distinct from what he terms "red copper." Both Behring and Kotzebue found copper implements in use among the Indians of the Northwest Coast.‡ McKenzie mentions copper as

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* Granville's Voy., 1585, in Pinkerton, vol. xii, p. 580.
† Heriot's Voy., 1586, in Pink., vol. xii, p. 594.
‡ Behring's First Voy., p. 85; Kotzebue, Voy., vol. i, p. 227.

being in common use among some of the extreme Northern tribes, on the borders of the Arctic Sea. "They point their arrows and spears with it, and work it up into personal ornaments, such as collars, ear-rings, and bracelets, which they wear on their wrists, arms, and legs. They have it in great abundance, and hold it in high estimation."* Owing to the difficulty of reducing iron from the ore, an acquaintance with that metal has usually been preceded by a knowledge of copper, silver, and gold. "These three metals," says Robertson, "are found in their perfect state in the clefts of rocks, in the sides of mountains, or in the channels of rivers. They were accordingly first known and applied to use. But the gross and stubborn ore of iron, the most serviceable of all metals, and to which man is most indebted, must twice feel the force of fire, and go through two laborious processes, before it becomes fit for use." Says Lucretius:

"Sed prius *æris* erat, quam *ferri* cognitus usus."

It was the difficulty of obtaining iron from the ores, or the possession of the art of so tempering or hardening copper as to make it answer most of the purposes to which steel is now applied, one or both, that perpetuated the use of bronze instruments in Egypt, as well as in Greece and Rome, long after those nations became acquainted with the former metal.

It may be regarded as certain, that the American aborigines, at the period of the discovery, were in ignorance of the uses of iron. It is true Vespuccius mentions a tribe of natives near the mouth of the La Plata, in South America, who possessed iron points to their arrows. It was probably obtained from native masses in that vicinity. The inhabitants of Madagascar obtain a part of their iron from such sources. A late traveller in Chile observes: "It appears that the Indians of Chile had, at the time of their discovery, in some very rare instances, iron blades to their lances; which led to the erroneous supposition that they were so far advanced in metallurgy as to be able to reduce and refine that metal from the ores. Our surprise will cease upon recollecting that this valuable metal already existed naturally in South America, in the very extensive deposits of native iron at *Santiago del Estero*, which has proved to be of meteoric origin, and differing from that at Zacatecas and Durango in Mexico, described by Humboldt, in the absence of earthy matter, and in not being, like them, in round masses, but in a horizontal bed of considerable extent and variable thickness, now for the most part covered with drifting sand, and resting on a bed of the same material."† Copper, on the other hand, seems to have been very

* Second Journey, p. 333.
† Mier's Travels in Chile, etc., vol. ii, p. 464.

abundant, and much used for implements, among all the semi-civilized nations of the continent. Columbus, when at Cape Honduras, was visited by a trading canoe of Indians. Amongst the various articles of merchandise which constituted their cargo, were "small hatchets, made of copper, to hew wood, small bells and plates, crucibles to melt copper, etc."* When the Spaniards first entered the province of Tuspan, they found the Indians in possession of an abundance of copper axes, which, in their greediness, they mistook for gold, and were much mortified on discovering their mistake. "Each Indian," says Bernal Diaz, "had besides his ornaments of gold, a copper axe, which was very highly polished, with the handle curiously carved, as if to serve equally for an ornament as for the field of battle. We first thought these axes were made of an inferior kind of gold; we therefore commenced taking them in exchange, and in the space of two days had collected more than six hundred; with which we were no less rejoiced, as long as we were ignorant of their real value, than the Indians with our glass beads." In the list of articles exacted as an annual tribute from the various departments of the Mexican empire, as represented by the Mexican paintings, were "one hundred and sixty axes of copper" from the southern divisions. * * *

The Peruvians used copper for precisely the same purposes with the Mexicans. Says La Vega, "They make their arms, knives, carpenters' tools, large pins, hammers for their forges, and their mattocks, of copper; for which reason they seek it in preference to gold." And Ulloa adds, "The copper axes of the Peruvians differ very little in shape from ours; and it appears that these were the implements with which they performed most of their works. They are of various shapes and sizes; the edge of some is more circular than others, and some have a concave edge."†

The knowledge of alloying was possessed by both the Mexicans and Peruvians, whereby they were enabled to make instruments of copper of sufficient hardness to answer the purposes for which steel is now deemed essential. Their works in stone and wood, whether in dressing the huge blocks of porphyry composing some of their structures, or in sculpturing the unique statues which are found scattered over the seats of their ancient cities, were carried on entirely with such instruments, or with still ruder ones of obsidian and other hard stones.

The metal used as an alloy was tin; and the various Peruvian articles subjected to an analysis, are found to contain from three to six per cent. of that metal. The chisel analyzed by Humboldt contained copper 94, tin 6.‡ A copper knife found in Peru by J. H. Blake, Esq., of Boston, contained about four per cent. of

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* Herrara, vol. i, p. 260. † Vol. i, p. 483. ‡ Res., vol. i, p. 260.

tin. This gentlemen informs me, that "The knives, gravers, and other implements found by myself in Peru, contain from three and a half to four per cent. of tin, which is sufficient to give them a very considerable degree of hardness.* The knives which I send you were found about the person of a mummy which I took from an ancient cemetery near Arico. Various household articles were found with it; but these were the only ones of metal, except a medal of silver suspended around the neck. The chisels or gravers are pointed at one end, with a cutting edge at the broad part. They were found at various places in the northern part of Peru. At the ancient city of Atacama, I found several hoes of copper, shaped very much like the 'grubbing-hoes' to be found in our warehouses." * * *

In 1831, arrow-points were discovered with a skeleton, near Fall River, Massachusetts. With this skeleton were found a corroded plate of brass, supposed to have constituted a breastplate, and a number of rude tubes of the same metal, composing a sort of belt or cincture. The arrow-points are two inches in length, and one and one-third inches broad at the base. This skeleton attracted a good deal of attention at the time, and was supposed to lend some sanction to the then popular theory of the early discovery and settlement of the coast of New England by the Northmen. An analysis of the compound metal of which the relics were composed, was made by Berzelius, under the direction of the Royal Society of Antiquaries of Denmark. The result of the analysis was published by that learned body, in the following comparative table:

	Copper.	Zinc.	Tin.	Lead.	Iron.
Brass from Fall River,	70·29	28·03	0·91	0·74	0·03
Old Danish,	67·13	20·39	9·24	3·39	0·11
Modern Brass,	70·16	27·45	0·79	0·20	——

It will be seen by the table, that the metallic relics found at Fall River bear in their composition a suspicious resemblance to modern brass. They certainly differ widely, in this respect, from any of the alloys of copper found elsewhere on the continent. Without alluding to the rudeness of the workmanship exhibited by the Fall River relics,—a rudeness entirely inconsistent with that stage of advancement indicated by a knowledge of smelting and alloying the metals,—the fact that the skeleton accompanying them was found buried, after the Indian mode, in a sitting posture, and enveloped in bark, places in a very strong light the probability that the burial was made subsequent to the first set-

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* The Indians of Chile, previous to the discovery by the Spaniards, made use of a kind of *bronze metal*, found native in the country, which is an alloy of copper, zinc, and antimony, called *campañil* by the Spaniards. From this they formed their cutting instruments.—*Mier's Trav.*, vol. ii, p. 464.

tlement of New England, in 1625, and that the relics were of native manufacture, from sheets or plates of brass obtained from the early colonists. This probability is further sustained by the circumstance that a portion of the wood attached to the arrows was still preserved, as was also a large proportion of the bark envelope of the skeleton, at the time of its discovery; which could hardly be the case, if its interment had been made as early as the tenth century, which is the period assigned to the Scandinavian visits. It cannot be claimed that the preservative properties of the salts of the copper could have more than a very local application or influence.

And while upon this point, it may be mentioned that Wood, in his "New England Prospect," published in 1634, (p. 90,) distinctly states that the Indians obtained brass of the English for their ornaments and arrow-heads, the last of which, he adds, "*they cut in the shape of a heart and triangle, and fastened in a slender piece of wood, six or eight inches long*"—in a manner, according to the description, precisely similar to that observed in the articles found with the Fall River skeleton. If any further evidence were needed to establish the opinions already advanced, it might be found in the fact that, a few years ago, in the town of Medford, near Boston, in Massachusetts, a skeleton was exhumed, accompanying which were found some flint arrow-heads, and some brass arrow-points, *identical* with those discovered at Fall River, together with a *knife of English manufacture* of two hundred years ago.

It has already been suggested that the shore of Lake Superior is the probable locality whence the copper used by the aborigines of, at least, the Eastern and Middle States, was obtained. This suggestion is rendered more than probable by the fact that abundant traces of aboriginal mining have been discovered there in the course of recent explorations. Some of the more productive veins in the "Copper Region" seem to have been anciently worked to a considerable extent. The vein belonging to the "Minnesota Company" exhibits evidence of having been worked for a distance of two miles. The ancient operations are indicated by depressions or open cuts on the course of the vein. Upon excavating these, ample proofs of their artificial origin are discovered, consisting of broken implements of various kinds, stone axes, hammers, etc. Traces of fire are also frequent. Some of the excavations are found to have extended to the depth of thirty feet. In the mine of the particular company above named, covered by fifteen feet of accumulated soil, and beneath trees not less than four hundred years old, was found a mass of pure copper, weighing 11,537 lbs., from which every particle of the rock had been removed. It had been supported by *skids* and was surrounded by traces of the fire which had probably been

used to disengage the rock. Here, too, were found various rude implements of copper.

At the Copper Falls and Eagle River, as at the Vulcan and other mines, the ancient shafts are frequently discovered. Professor W. W. Mather, the eminent geologist, in a private letter, referring to the two mines first named, says: "On a hill, south of the Copper Falls Mine, is an excavation, several feet in depth and several rods in length, extending along the course of the river. Fragments of rock, etc., thrown out of the excavation, are piled up along its sides, the whole covered with soil, and overgrown with bushes and trees. On removing the accumulations from the excavation, stone axes of large size, made of green-stone, and shaped to receive withe handles, are found. Some large round green-stone masses, that had apparently been used for sledges, were also found. They had round holes bored in them to the depth of several inches, which seem to have been designed for wooden plugs, to which withe handles might be attached, so that several men could swing them with sufficient force to break the rock and the projecting masses of copper. Some of them were broken, and some of the projecting ends of rock exhibited marks of having been battered in the manner here suggested."

The great Ontonagon mass of virgin copper, now deposited at Washington, when found, exhibited marks of having had considerable portions cut from it; and the ground around it was strewed with fragments of stone axes, which had been broken in endeavors to detach portions of the mass. It is not impossible that this mass was one of those which had been brought to the surface by the ancient miners.* The questions naturally arise, By whom were these ancient mining operations carried on? and to what era may they be referred? Without noticing the improbable suggestion, that the various excavations which have been discovered are due to the French, (who, it is well known,

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* Since the above was written, the subjoined additional facts have been published in the Lake Superior Journal newspaper, of the date of September 25, 1850:

"We have been shown by Charles Whittlesey, Esq., of the Ontonagon Mine, a copper arrow-head, and a piece of human skull and other bones, which have lately been found in the ancient Indian excavations on the Ontonagon River. The arrow-head is now about two inches in length, and seems to have had originally a socket, though but part of it remains. Several chisels, or instruments resembling chisels, having sockets like the common carpenter's chisel, and small gads or wedges, have also been found at the Minnesota Mine.

"But the greatest curiosity we have seen in the way of these articles is a stick of oak timber lately taken out of one of the ancient 'pits,' or shafts, at the Minnesota Mine, twenty-seven feet below the surface. It is a small tree, about ten feet in length, and eight or ten inches in diameter, having short limbs two feet apart, and at nearly right angles with one another; and on this account, and from its standing nearly upright, it is supposed to have been used as a ladder by the ancient miners. In this shaft, and around and over this stick, were rocks and earth, and large trees were growing over it. Many centuries must have elapsed since that ancient ladder was placed there."

were early acquainted with the mineral riches of the Northwest,) we may find a satisfactory answer to the first of these questions, if not to the last, in the character of the deposits which recent explorations have disclosed from the mounds of the West. Among the multitude of relics of art found buried upon the ancient altars, or beside the bones of the dead, articles of copper are of common occurrence. It is sometimes found in native masses, but generally worked into articles of use or ornament. I have taken from the mounds, axes, well wrought from single pieces, weighing upwards of two pounds each. They are symmetrical, corresponding very nearly in shape with the Mexican and Peruvian axes. Some are double-bladed, others *gouge-shaped*, and evidently designed to be used as adzes. Besides these, chisels, graving tools, and a great variety of ornaments, bracelets, gorgets, beads, etc., etc., composed of this metal, have been discovered. Some of the ornaments are covered with silver, beaten to great thinness, and so closely *wrapped around* the copper that many persons have supposed that the ancient people understood the difficult art of plating.

Some years ago, a mass of native copper, weighing upwards of twenty pounds, was found upon the banks of the Scioto River, near Chilicothe, in Ohio. Large portions had evidently been cut from it. The discovery of these native masses, not to mention the amount of manufactured copper, implying a large original supply, points pretty certainly to the shores of Lake Superior as the locality whence the metal was obtained. There are other circumstances, still more conclusive, and which, taken into connection with the traces of ancient mining in the mineral region, leave no room to doubt that the race of the mounds obtained their supplies of copper from that direction. It is well known that while some of the Lake Superior copper is almost perfectly pure, a part is alloyed with silver in various proportions, and some is found having crystals of silver attached to it,—a peculiar *mechanico-chemical combination*, known to exist nowhere except in this region. This characteristic combination has been observed in some of the specimens, both worked and unworked, found in the mounds, and enables us to identify fully their primitive locality. The great industry and skill which the mound-builders displayed in the numerous and often gigantic monuments which they have left us at the West, warrant us in ascribing the ancient excavations, etc., in the mineral region to them. The Indian hunter is proverbially averse to labor; and we have no instance of the Indians undertaking works of this extent. Still, it cannot be doubted that they also obtained copper from this region. Indeed, we have direct evidence of the fact; but it is probable that they procured it only in small quantities, when it was found exposed at the surface, or on the banks of streams. Alexander

Henry, who penetrated to Lake Superior at the period of the second French war, assures us that the Indians obtained copper here, which they "made into bracelets, spoons," etc.* As we have seen, the early explorers on the coasts of New England, New York, Virginia, the Carolinas, and Florida, among whom we may mention Hudson, Verrazano, Raleigh, Heriot, Ribaude, De Soto, all concur in saying that the Indians had copper in small quantities among them, which they worked into pipes and ornaments. De Soto found copper hatchets among some of the tribes along the Gulf, which they professed to have obtained from "a province called *Chisca*, far toward the North."

All the copper found in the mounds appears to have been worked in a cold state; and although the axes and other instruments appear to be harder than the copper of commerce, they have been found, upon analysis, to be destitute of alloy. The superior hardness which they possess over the unworked metal, is doubtless due to the *hammering* to which they have been subjected. Some of the sculptures in porphyry, and other hard stones found in the mounds, exhibit traces of having been *cut;* but as they now turn the edge of the best tempered knife, we are at a loss to conjecture how they were so elaborately and delicately worked. The lack of cutting implements, among most rude people, is partially met by various contrivances, the most common of which is attrition, or rubbing or grinding on hard stones. It was thus the stone axes, etc., of the early Indians were slowly and laboriously brought into shape. It however needs but a single glance at the mound sculptures to convince the observer that such rude means are wholly inadequate to the production of works possessing so much delicacy of execution.

The Mexicans and Peruvians were wholly unacquainted with the use of iron; and their carvings, etc., were all wrought with copper tools. They, however, contrived to harden them with an alloy of from three to seven per cent. of tin. I have some of their implements in my possession, which answer a very good cutting purpose. It nevertheless seems incomprehensible how their extensive works in granite, porphyry, and other obstinate materials, could be carried on with such aids. The Egyptians, although not ignorant of iron, were compelled, by a variety of circumstances, to use copper tools, and with these most of their gigantic labors were effected. They must of necessity have had some means of hardening the metals; yet it is a singular fact, that, with the exception of a few bronze weapons of probably a comparatively late date, the chisels and other implements found in the monuments and at the quarries are *pure copper.*

Use of Silver by the American Aborigines.—Granville, as we have seen in the quotation from his voyage on page 177, speaks

* Travels, p. 195.

of finding pieces of silver amongst the Virginia Indians, "grossly beaten," and used for purposes of ornament. Having shown that the copper found amongst the Indian tribes of the north was probably obtained from the native deposits around Lake Superior, we have little difficulty in accounting for the presence among them of small quantities of silver, derived from the same locality, where it also exists in a native form. That the silver in use amongst the mound-builders was principally if not wholly obtained there, seems incontestible. In no instance does it appear to have been smelted.

A variety of silver ornaments were discovered some years ago in one of the mounds at Marietta, Ohio, under very singular circumstances, and in a remarkable connection. The circumstances have been detailed by the accurate pen of Dr. S. P. Hildreth, in a communication to the President of the American Antiquarian Society, dated "Marietta, Nov. 3, 1819."

"In removing the earth composing an ancient mound in the streets of Marietta, on the margin of the plain, near the fortifications, several curious articles were discovered. They appear to have been buried with the body of the person to whose memory the mound was erected.

"Lying immediately over, or on the forehead of the body, were found three large circular bosses, or ornaments for a sword-belt or a buckler: they are composed of copper overlaid with a thick plate of silver. The fronts are slightly convex, with a depression like a cup in the centre, and measure two inches and a quarter across the face of each. On the back side, opposite the depressed portion, is a copper rivet or nail, around which are two separate plates, by which they were fastened to the leather. Two small pieces of the leather were found lying between the plates of one of these bosses; they resemble the skin of a mummy, and seem to have been preserved by the salts of copper. The copper plates are nearly reduced to an oxyd, or rust. The silver looks quite black, but is not much corroded, and in rubbing is quite brilliant. Two of these are yet entire; the third one is so much wasted that it dropped in pieces in removing it from the earth. Around the rivets of one of them is a small quantity of flax or hemp, in a tolerable state of preservation. Near the side of the body was found a plate of silver, which appears to have been the upper part of a sword-scabbard; it is six inches in length and two inches in breadth, and weighs one ounce. It has no ornaments or figures, but has three longitudinal ridges, which probably corresponded with the edges or ridges of the sword; it seems to have been fastened to the scabbard by three or four rivets, the holes of which remain in the silver.

"Two or three broken pieces of a copper tube were also found, *filled with iron rust.* These pieces, from their appearance, composed the lower end of the scabbard, near the point of the sword. No signs of a sword itself were discovered, except the appearance of rust above mentioned. Near the feet was found a piece of copper weighing three ounces [now in the Museum of the Antiquarian Society of Worcester]. From its shape it appears to have been used as a *plumb*, or for an or-

nament, as near one of the ends is a circular crease or groove, for tying a thread: it is round, two inches and a half in length, one inch in diameter at the centre, and half an inch at each end. It is composed of small pieces of native copper pounded together; and in the cracks between the pieces are stuck several pieces of silver, one nearly the size of a half-dime. A piece of red ochre or paint, and a piece of iron ore [*hematite*] which had the appearance of having been partially vitrified [*polished?*], were also found.

"The body of the person here buried was laid upon the surface of the ground, with the face upwards, and his feet pointing to the southwest. From the appearance of several pieces of charcoal and bits of partially burned fossil coal, and the black color of the earth, it would seem that the funeral obsequies had been celebrated by fire; and while the ashes were yet hot and smoking, a circle of these flat stones had been laid around and over the body. The circular covering was about eight feet in diameter; and the stones yet look black, as if stained by fire and smoke. This circle of stones seems to have been the nucleus over which the mound was formed, as immediately over them is heaped the common earth of the adjacent plain. At the time of opening it, the height was six feet, the diameter between thirty and forty. It has every appearance of being as old as any in the neighborhood, and was, at the settlement of Marietta, covered with large trees. It seems to have been made for this single personage, as the remains of one skeleton only were discovered. The bones were much decayed, and many of them crumbled to dust on exposure to the air."

The silver-plated discs and also the embossed silver plate supposed by Dr. Hildreth to have been a sword ornament, have been critically examined, and it is beyond doubt that the copper "bosses" are absolutely *plated*, not simply overlaid, *with silver*. Between the copper and the silver exists a connection, such as, it seems to me, could only be produced by heat; and if it is admitted that these are genuine remains of the mound-builders, it must, at the same time, be admitted that they possessed the difficult art of plating one metal upon another. There is but one alternative, viz., that they had occasional or constant intercourse with a people advanced in the arts, from whom these articles were obtained.

ART. XXXIV.—*On the corrosion of an Alloy, composed of Copper and Silver, in Sea-water;* by AUG. A. HAYES, Assayer to the State of Massachusetts.

SOME analyses I made many years since of sheathing copper, which had long resisted the action of sea-water, proved the presence of nearly one ten-thousandth part of silver. It was found that even this small portion of silver, sensibly modified the chemical relations of the metal, and observations had indicated that the quality for sheathing, was improved.

Copper of this kind, is frequently met with in commerce and is derived from the Chilian ores of copper, which although argentiferous, do not yield enough silver, to render its separation economical.

An occasion offered for again examining this subject, when the argentiferous native copper of Lake Superior was first refined and rolled by the Revere Copper Company, more than five years since, and the results have lately been obtained.

Four suits of sheathing, for large merchant vessels, formed the subjects for observations, the metal being of uniform composition, as determined by assay of the clipping from many sheets. Two thousand parts of the alloy contained 4 parts of pure silver, or the standard ton of this country contained 4 lbs. of silver.

A *proximate* analysis of this metal was also made, and it proved to be pure copper, throughout the mass of which, an alloy of silver and copper was evenly distributed, so as to form either a mixture, or a compound alloy, in which one part of the copper is truly combined with the silver and the other larger part, simply combines with the alloy. This is a very common constitution of alloys, in which two metals exist, without any metalloid occurring to disturb the simplicity of the union and always indicates, a careful purification of the metals.

It was assumed as probable, that the silver alloy would close the pores of the copper which takes place with a tin alloy in bronze and in a mechanical way, confers durability. If however, corrosion should take place, it was in accordance with observed cases that the silver alloy would act as a negative element, and the copper alone would be removed. How erroneous these inferences proved, will be seen in the detail of the results.

The "Chicora" was coppered Jan. 9, 1847, taking 7,392 lbs. metal, which was fastened by bronze nails. She was employed in trade to China and wore her copper so rapidly, that it was removed in March, 1849, 2,628 lbs. only remaining. In this case the sheets after the usual operations, had been consolidated by "cold rolling."

The "Serampore" was coppered January 18, 1847, requiring 8.447 lbs. of "cold rolled" metal, secured by bronze nails. She sailed to China and home, *via* Cape of Good Hope, and to the Pacific and home, *via* Cape Horn, requiring new copper in March, 1850. The weight of the remaining copper, was not ascertained.

The "Hamilton" was coppered October 22, 1847, requiring 7,706 lbs. metal, secured by bronze nails. The sheets used were in the ordinary or annealed state. This vessel was employed in the India trade and wore out her copper in August, 1849. The weight of the copper remaining was 3,086 lbs.

The "Carthage" was coppered November 26, 1847, requiring 8,727 lbs. "cold rolled" metal fastened by bronze nails. She

was employed in the India trade and her sheathing was destroyed in August 1849. The copper remaining, weighed 5,810 lbs.

Omitting the case of the "Serampore" where the corrosion cannot be determined by weight, we have the loss in every one hundred parts of metal, for the time of duration,—thus,

The "Chicora," twenty-seven months, lost 64·45 per 100
"Hamilton," twenty-three " " 59·95 " "
"Carthage," twenty-one " " 33·45 " "

Allowing the same rate of corrosion and taking the time as twenty-seven months for each,

The "Chicora" lost - - 64·45 in 100
"Hamilton" - - - 70·38 " "
"Carthage," - - - 43·00 " "

In the cases of the "Hamilton" and "Carthage," we perceive the influence of the different processes of manufacturing the sheets, on the durability of the copper. By the operation of "cold rolling," the surfaces of the sheets are rendered very compact, and in any corroding solution, they bear a negative relation to the metal in the same sheets, between these surfaces. Such copper is also always strongly negative to annealed copper in acid solutions, until the hardened surfaces are removed, it then loses this relation. The "Hamilton" exhibits the greatest effect of sea-water action on the annealed alloy, while in the Carthage, the protecting influence of the hardening surface, was exerted nearly to the time her copper was removed.

These observations establish the fact of the rapid corrosion of an alloy thus constituted, and show its entire unfitness for sheathing purposes.

The average duration of copper sheathing decreases slightly, as the requirement of greater speed in sailing is more urgent. Taking one hundred merchant ships, sailing on different oceans, the average duration now on American ships, is three years.

On the point of the *kind* of corrosion, following the exposure of the alloy to sea-water and air, the information obtained in these trials, is of a definite character. Part of the sheets remaining and an ingot of the copper from smelting a large quantity, were assayed and the results showed that, the same proportion only of silver remained, as was originally contained in the alloy. The silver alloy therefore, by taking the negative state in the mass of the metal, hastened its destruction, while its own form and condition were such, that it separated as the copper, was corroded.

For the records of facts and much assistance continued for years, in connection with the subject of copper corrosion, I am indebted to the kindness of my friend, Mr. J. Davis, Jr., Treasurer of the Revere Copper Company.

1 Pine st., Boston, January 30, 1851.

Art. XXXV.—*On the Calculus of Operations*; by John Paterson, A.M.*

In the algebraical and other forms of calculus in vogue, the various quantities, numbers. symbols, functions, etc., constituting the matter of the science, are understood as ratios of *magnitudes* merely as such. The expressions x, x^2, x^3, for example, are ratios of the magnitudes $x1$, $x^2.1^2$, $x^3.1^3$, to the unit magnitudes 1, 1^2, 1^3, respectively; the units 1, 1^2, 1^3, representing a line, a square surface, and a cubical volume respectively. But as all geometrical magnitude is confined to one, two, or three dimensions, it follows, that while such expressions as x^4, x^5, etc. are ratios of $x^4\,1^4$, $x^5\,1^5$, etc. to 1^4, 1^5, etc., these units of comparison can no longer represent geometrical magnitudes. The question arises, what do these units signify? They are complex units of number. But, we ask, numbers, or number of what? Wherein does 1^4, 1^5, etc., differ from 1? *Number* is a general idea, and therefore must be applicable to several particular instances. If then a particular instance of geometrical unity can be found, to which all other powers and roots of unity can be referred as a base, we shall be prepared to answer the preceding question. The Calculus of Operations professes to have discovered such base, and to have broached the method and traced the route which leads to the most general interpretation of the functions of unity. By this calculus, all functions are regarded as ratios of the measures of operations performed in space and time; for example, the expression x^4 is the ratio obtained by comparing the operation whose measure is $x^4\,1^4$, with that whose measure is 1^4; the latter being a compound unit of operation, ultimately referable to a simple unit of space, a linear unit.

Addition is an operation, in which we take for unit measure of operation the distance through which the *added* body is transfered in the unit of time; each unit of the recorded result expressing the performance of *one* operation of addition, and indicated geometrically by the unit of length drawn to the *right* of an origin.

Subtraction is an operation diametrically opposed to that of addition, and will therefore be indicated geometrically by the unit of length (measure of operation) drawn to the *left* of an origin.

Multiplication is an abridged method of performing a series of additions; so that when the multiplier is unity, the operation coincides with the performance of one addition. Consequently

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* This article was received by the editors along with the recent work of Mr. Paterson, entitled, "The Calculus of Operations." 184 pp., with 4 plates. Albany, 1850—Gray and Sprague. The merit and peculiar views of the work will be gathered from this exposition of the subject by the author.

successive multiplications by unity, or the involution of a geometrical unit, will be geometrically interpreted by so many successive productions of the linear unit to the right of the origin. This informs us that the nth power of a linear unit is a line of n times the length of the line involved, or that $1^4 = 4.1$ by this method. But if, instead of a linear unit, we take for a geometrical multiplier the nth part of the circumference of a circle to radius unity, the performance of n successive multiplications will transfer the *multiplied* body (multiplicand) around the circumference, by n successive steps, to its point of departure; at which point it had the measure unity (the radius of the circle), and therefore we now have $1^n = 1$, or the powers of geometrical and arithmetical unity may be made to coincide. Inversely, if the entire circumference be taken for geometrical unit, its nth part will represent the nth root of unity. The discussion of the two cases in which n is equal to 2 and to 4, furnishes a complete logical demonstration of the properties of the four algebraical signs; for which, see the second and last chapters of the Calculus of Operations. In all cases the distances traversed have a dynamical value, as measures of the respective operations of describing them.

Division is an operation compounded of addition and subtraction; wherein the quotient, which is a pure ratio, is retained as the measure of the result of the operation, which consists in effecting an equilibrium between the forces of which the dividend and divisor are the measures.

In the fluxionary calculus, the various functions or complex ratios are treated by the analyst as though they were primitive existences, or productions furnished by the hand of nature. Just as the chemist collects his specimens of mineral substances from the bowels of the earth, and proceeds to decompose and analyze them by the application of fire; so the analyst takes his given functions, and proceeds to analyze them by differentiation after the method of Leibnitz, or by derivation according to Lagrange. The calculus of operations, on the contrary, proceeds synthetically, and actually shows how to construct the ratio, or how the function may be generated, and thereby furnishes an irrefragable demonstration of its constitution. The theory of generating powers comes in for a large share in the operations of general algebra, and has an ample bearing upon our views of the philosophy of nature. By this theory alone, unaided by and uninterfering with the notion either of infinitesimals or of limits (except so far as merely to show their necessity for the production of certain particular classes of phenomena), the theorem of Taylor, which is the acknowledged basis of all mathematical development, is directly established in its most general form, and the analogy between symbols of operation and of quantity receives its fullest generalization. Lagrange's theory of derivation shows

how, when the primitive function is given, all the successive derivatives are to be obtained from it; but the theory of generation evolves the primitive, together with its derivatives, all by one same process.

Generation is still an *operation*, but characteristically distinguished by its result, which is, in general, itself a *generator*, or an *operator* of an order or rank next inferior to that of its own generator.

A constant velocity causes a body, or material unit, to describe a distance which increases uniformly, or as the time; and will therefore generate the distance unity (linear unit) in the unit of time, and consequently the distance whose ratio is x in x units of time. A constant velocity, therefore, has but one measure of operation, namely the unit of distance, and thus corresponds exactly with multiplication by linear unity.

A constant force generates velocity uniformly; and this velocity, from the very commencement of its existence, operates upon the material unit, and causes it to describe the unit of distance in the first unit of time. But at the expiration of this first unit of time, the amount of velocity, having increased uniformly during that time, is evidently such as will of itself cause the material unit to describe *twice* the distance in the immediately succeeding unit of time, that was described by it in the preceding unit of time; that is, the velocity generated in the unit of time has *two* units of distance for its measure in the succeeding unit of time, and *one* unit of distance for its measure in the unit of time during which it was itself generated by the constant force. Or we may say also, that the constant force has at once *two* measures of operation: first, an *immediate* measure, the velocity *two*, generated in the unit of time; and, secondly, the *mediate* measure *one*, being the distance generated by the velocity during its own generation. Since the *two* units of velocity were *uniformly* generated in the unit of time, it follows that exactly *one* of these velocities was generated in each semiunit of time; that is to say, the constant force performs *one operation* in the semiunit of time; or, in general, a semiunit of time is the interval occupied in the performance of *one* genetic operation, in which the result itself is a generator. From these considerations, we readily find that the velocity increases as the duplicate of the time, and the distance as the square of the time; and we have now discovered a method which enables us to raise the dimensions of a ratio x.

Assume a series of subordinated generating forces, or more generally a hierarchy of generating powers, such that the power of the lowest order shall correspond to a constant velocity, which generates distance (power of the order zero) uniformly: the power of the second order shall correspond to a constant force, which generates velocity uniformly; the power of the third or-

der, which generates power of the second order uniformly; the power of the fourth order, which generates power of the third order uniformly, etc., etc.

By deduction it is found, in the case of the power of the third order, which performs *two* genetic operations in the unit (one in each semiunit) of time, thereby generating two units of power of the second order, that the two generated powers of the second order together perform three genetic operations in the first unit of time, thus generating three powers of the first order; which three powers, during their own genesis generate the power zero, or unit measure of operation or distance. And from these considerations we find that the generated power of the second order increases as the duplicate of the time, the velocity increases as the triple square of the time, and the distance as the cube of the time.

The power of the fourth order performs two operations, or generates two powers of the third order in the first unit of time; which two powers of the third order together perform three operations, or generate three powers of the second order in the same unit of time; which three powers of the second order together perform four operations, or generate four powers of the first order in the unit of time; and finally the four powers of the first order generate the power of the order zero, or unit of operation or distance in the first unit of time. Each generated power, after its generation, becomes in its turn a primitive generator, and generates its proper hierarchy of powers; and when the measures of their several results are reduced in the proportion of those of the independent primitive generator, they yield the several terms of the fourth power of a binomial. We find that the generated power of the third order increases as the duplicate of the time, the power of the second order increases as the triple square of the time, the velocity increases as the quadruple cube of the time, and the distance increases as the biquadrate of the time.

These examples are sufficient to show that the process may be extended to any required positive number n; and thus when the operations performed are genetical, our calculus shows the direct genesis of any positive power of any given number x; while we have seen that when the operations were performed by a power of the first order, they corresponded to successive multiplications, and served merely to determine the powers of a geometrical unit. Now when the successive multiplications are effected by semi-revolutions around a centre or origin of measurement, we exhibit the successive powers of negative unity; and similarly by combining the principle of revolution with our genetical operations, we are enabled to show the genesis of negative and fractional powers of x. Other conditions are readily assigned, which determine the several forms of exponential series, together with their trigonometrical and logarithmical relations.

The entire structure of the Calculus of Operations is based upon the principle of *uniformity of action*. Under this principle, when the order of the primitive operator is higher than unity, the final result will be a corresponding power of the general number x; but when the operator is of the first order only, we get powers of unity.

It is conceived that a uniform action is susceptible of accurate measurement in its immediate result, which must necessarily increase uniformly in time; and when this result is also an *actor*, the rate at which its *effect* increases is to be deduced in conformity with the first principles of uniform action of the primitive actor, and is to be expressed in time and number of operations, which are ultimately referred to space in the final result.

The dimension of the simplest form of extent can only be determined by means of an operation, to wit, the operation of measurement. Time, which itself is no *magnitude*, is yet susceptible of measurement in space; and the operation of effecting this measurement involves an expenditure of force, the measure of which is precisely equivalent to, or identical with, that of the time which it records. And so of all magnitudes whatever, their measure implicitly contains the measure of the force expended in effecting their measurement, which may be taken cognizance of for the purpose of furthering the progress of calculation; and conversely, all operations, addition, subtraction, multiplication, etc., have their measure in space and time. These measures have generally been overlooked in analytical operations; but by recognizing and restoring them to their legitimate place on our tablets, we fill up the hiatus which otherwise exists between the *mise en equation* and the final answer.

The principle of uniformity of action, it is believed, will be found to hold a place in algebraical logic, similar to that held by the celebrated *dictum de omni et nullo* in the logic of Aristotle. It is believed, also, that the preliminary scheme of classification comprises the categories of existence complete; that these categories are not merely subjective, like those of the system of Kant, but have full objective validity; and that they are not liable to the charge either of deficiency or redundancy, as are the famed categories of Aristotle.

It is to be recollected that this is the first publication of the discoverer of this method (if peradventure it shall be admitted to the title of *a method*), and that it is given in the form of researches merely, which only point to the definitive form of the calculus. As an instance of its fertility in analogy and interpretation, it may be remarked, that in ordinary multiplication, the linear unit (unit of operation) is constant, and successive multiplication merely increases the dimensions of x, as $1, x, x^2, x^3$, etc. But when it is shown how the unit of operation may in-

crease with the time x, we obtain the series $1, 1x, 2x^2, 3x^3$, etc., wherein appears the leading numerical factor concerned in the process of differentiation: or if the unit of operation be negative, the series becomes $1, -1x, +2x^2, -3x^3, +$ etc., corresponding to the differentials of a negative function: and finally when the unit of operation is circulative, we enter upon the differentiation of exponential functions. Nature, in the case of a body falling in a vacuum under the influence of the force of gravitation, actually develops the function $(x+h)^2$; and it is the intention of the Calculus of Operations to exhibit the harmony which subsists between the objective and subjective, between the phenomena of the external world, and the mental processes which investigate and record them.

ART. XXXVI.—*On the Mammoth Cave of Kentucky;* by Prof. B. SILLIMAN, Jr. (From a letter addressed to Prof. Guyot, Cambridge; dated Louisville, November 8, 1850.*)

I HAVE lately had an opportunity of visiting the Mammoth Cave of Kentucky and have made in connection with Mr. R. N. Mantell a collection of the animals found there, which we propose to send to our m ich valued friend, Prof. Agassiz, by an early opportunity. My object in writing to you is to say a word regarding the general topographical features of the country and some other matters which I suppose will interest you.

At the level of the Ohio below the falls on which the city stands, are found the lower beds of silurian rocks and upper Devonian, the oldest palæozoic rocks to be seen in all this region. This city is placed on a plateau elevated some seventy-five feet above the low-water mark of the Ohio, and the plain on which it stands represents the general level of the surrounding country for a long distance above and below. Mammoth Cave lies in a direction nearly south of Louisville on the Green river and on the direct road to Nashville, midway between Louisville and the latter city. Leaving Louisville, the stage road follows the main course of the Ohio and generally along its banks to the Salt river, some twenty miles; crossing this river the road bears south, leaving the Ohio on the right, and soon enters a new region. By a gentle and easy ascent you continue to rise for several miles by a circuitous path, passing in succession all the members of the si-

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[* The following letter was written with no intention of its being published and only for the gratification of a friend, who has since urged its publication. It is therefore given exactly as it was first written, which may, I trust, be deemed a sufficient apology for whatever want of fullness of detail attaches to a general and rapid sketch.—B. S., Jr.]

lurian and the lower secondary or the mountain limestone until at an elevation of 300 to 400 feet above the Ohio you reach the great upper plateau which stretches away for a long distance, interrupted only by the deep river beds, which are all very nearly on the same level with the Ohio. These upper plains are called the '*Barrens*,' from the general sterility of the soil, which is formed to a considerable extent of stiff red clays and unproductive sands, or of lime rocks lying near the surface. Everywhere in this upper country we are struck with the frequent occurrence of those circular holes or shallow pans which are called 'sinks,' from the popular belief that the surface has fallen away or sunk at some recent period. You see large trees standing dead in the water which fills these hollows, in a situation where of course they could not have grown supposing the water had long occupied its present place. Hence the idea so generally accepted that the surface of the earth has fallen downward, and this is attributed to the wearing away of the rocks beneath by subterranean rivers or by some other mode of aqueous action. It is probable that the hollows, already existing, are made water-tight by the cementing of the surface by fine mud floated by rains from the adjacent roads. I saw hollows of this sort standing full of water in this very dry season, in which the trees were not quite dead, while in others only the denuded trunks were seen. From these stagnant pools arise the poisonous miasms that produce the fevers which are peculiarly abundant in those parts of the Barrens where the sinks are most numerous. It is remarked that the 'sinks' have greatly increased in number, and the miasms in virulence, since the country was opened by cultivation and by roads. These causes have obviously operated to furnish the slime which the rains have washed down into the circular hollows adjacent these improvements, thus rendering them water-tight.

The stage-road to Nashville runs over this upper plateau all the way from Salt river with unimportant exceptions in the valleys of small rivers, until it reaches the valley of the Cumberland river, over one hundred and fifty miles. Within some ten or fifteen miles of Nashville the traveller again descends by a similar gradual declivity full 350 feet to the banks of the Cumberland river, on which the city of Nashville stands. Here again the observer detects the oldest silurian rocks. compact blue crystalline limestones in which the fossils are almost obsolete, and unfossiliferous sandstones, alternating with them.

The Mammoth Cave of Kentucky is situated in the midst of the great upper plain and descends from the uppermost rocks to those which are nearly or quite on a level with the Ohio. . Dr. John Locke of Cincinnati has measured the depth of the cave barometrically, and is said to have determined it to be 325 feet

below the hotel, and the level of the rivers of the cave to be the same as that of Green river with which the subterranean rivers or lakes rise and fall in times of flood; so that there is no doubt of a connection existing between Green river and these curious subterranean pools over which the explorer passes in mysterious silence many miles from the entrance, and at least 300 feet from the upper surface. Unfortunately our party was unprovided with barometers, and the measurement of Dr. Locke remains therefore as the only evidence we have of the relative levels of these subterranean waters and Green river.

One atmospheric phenomenon attracted our attention and tasked our ingenuity for a satisfactory explanation. I will mention the fact and our solution of it. If the external air has a temperature above 60° F., the observer, on approaching the mouth of the cave, is met by a blast of cool air blowing outward from the mouth; and if the external temperature is high, say 90° F., the blast amounts to a gale. It is almost impossible, indeed, where the difference of temperature, either way, is considerable, to make the entrance of the cave with a lighted lamp; unless carried with an experienced hand it is surely extinguished. In hot weather, this contrast of temperature and its accompanying blast of air, are at first quite overpowering and you feel as if immersed in a cold bath.

If the air without has a temperature of 59°–60° no current is observed and the flame of a lamp held in a favorable position indicates none. It immediately occurred to me that there must be two currents, one above of warmer air, passing inward, and one below of colder air passing outward, and the reverse, but experiment soon satisfied me that this was not the case. Only one current could be discovered, and on inquiry of the very intelligent guide, 'Stephen,' who is well known for his remarkable powers to all who have been at the cave, I found that this phenomenon had attracted his attention, and that he was satisfied from many observations that only one current existed and that this flowed *out* when the external air was above 60° and *inward* when this was below 60°. Going in, one day at noon, we found the outward blast very strong: we prolonged our stay until past midnight; meanwhile a storm of rain accompanied by lightning had come up, and at 3 A. M. when we again emerged, the temperature outside had fallen to 50°, and the inward gale blew so strongly as to extinguish our lights several hundred yards from the mouth. In fact the guide told us, when more than two miles in the cave, that a change had taken place in the outer air, and that we should probably find a storm raging without. His accustomed senses detected the gentle current inward which we did not notice at so great a distance, and he perceived, as he afterward told us, a change of level in the subterranean rivers since

our crossing them in the morning—the rain which had fallen copiously having already affected them.

I was at a loss for a little time to account for these currents of air, but the following explanation suggested itself. The mouth of the cave is the only communication between the external air and the vast labyrinth of galleries and avenues which stretch away for many miles in the solid limestone. The extent of these underground valleys of denudation, or rather 'excavations,' is vastly greater than I had imagined before going there; branching, crossing, inosculating in all directions, and at all levels, the mind is lost in amazement at their vast proportions, the various beauty which they possess, and at the continuity of the cause which has formed them. The air which they contain is pure and exhilarating. The nitre beds which are of incredible extent in these galleries probably account in part for the purity of the air, as the nitrogen which is consumed in the formation of the nitrate of lime must have its proportion of free oxygen disengaged, thus enriching this subterranean atmosphere with a larger portion of the exhilarating principle. The temperature of the cave is uniformly 59° F., summer and winter, and this is probably very near to the annual mean of the external air. The expansion which accompanies an elevation of temperature in the outer air is immediately felt by the denser air of the cave, and it flows out in obedience to the law of motion in fluids, and the outward current continues without interruption as long as the outer air is possessed of a higher temperature than the cave.

I was assured by those resident on the spot, that for weeks or even months, in the summer and winter, this blast of air continues with unabated force outward or inward, and yet the thermometer at a distance from the mouth always indicates the same temperature. This seems to me of itself a very convincing proof of the vast volume of the subterranean galleries; for otherwise the equilibrium being soon restored, the current would cease, or the temperature within would vary. Still it must be regarded as an interesting place for a series of observations with the barometer and thermometer continued daily for a year, and it would not be difficult to arrange such a series, if the question was esteemed to possess sufficient scientific interest to warrant the expense. If the cave had two openings at different levels. the temperature would not be uniform and there would be two currents discernible.

There is no exception to the purity of the air in the Mammoth Cave, in none of the deep pits or domes is it possible to find any accumulation of carbonic acid or other noxious gases, respiration and combustion are perfect in all parts which have yet been visited. The waters of the springs and rivers within it are all limpid and potable, and the avenues with few exceptions are dry at all seasons. I thought it very remarkable that in all its vast extent

there should be no sources of sulphuretted hydrogen and of carbonic acid.*

The phenomena of life within the cave are comparatively few but interesting. There are several insects, the largest of which is a sort of cricket with enormously long antennæ. Of this insect, numerous specimens will be found among the specimens sent to Prof. Agassiz. There are several species of Colcoptera, mostly burrowing in the nitre earth. There are some small water-insects also which I suppose are Crustacean. Unfortunately three vials containing numerous specimens of these insects were lost with my valise from the stage coach, and I fear will not be recovered. Of the fish, there are two species, one of which has been described by Dr. Wyman in the American Journal of Science, and which is entirely eyeless;† some ten or twelve specimens of the species were obtained. The second species of fish is not colorless like the first, and it has external eyes, which however are found to be quite blind.‡ The craw-fish or small crustacea inhabiting the rivers with the fish are also eyeless and uncolored, but the larger-eyed and colored craw-fish which are abundant without the cave, are also common at some seasons in the subterranean rivers, and so also it is said the fish of Green river are to be found in times of flood in the rivers of the cave. Among the collections are some of the larger-eyed craw-fish which were caught by us in the cave. The only mammal except the bats, observed in the cave, is a rat which is very abundant, judging from the tracks which they make, but so shy and secluded in their habits that they are seldom seen. We caught two of them, and fortunately male and female.

The chief points of difference from the common rat in external characters, are in the color, which is bluish, the feet and belly and throat white, the coat which is of soft *fur* and the tail also thinly furred, while the common or Norway rat is gray or brown, and covered with rough hair. The cave rat is possessed of dark black eyes, of the size of a rabbit's eye and entirely without iris; the feelers also are uncommonly long. We have satisfied ourselves that he is entirely blind when first caught, although his eyes are so large and lustrous. By keeping them however in captivity and diffuse light they gradually appeared to attain some power of vision. They feed on apples and bread, but will not at present touch animal food. There is no evidence that the cave rats ever visit the upper air, and there was no one who could tell me whether they were or were not found there by the persons who first entered this place in 1802.

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* Near "Mary's Bower" there is a spring of bitter water evidently containing sulphate of magnesia, which salt is also found abundantly in some parts of the cave.

† See also Proceedings Bost. Soc. Nat. Hist., 1850, 349.

‡ For a list of the animals found in the cave as mentioned by Prof. Agassiz, see this volume, page 127.

Bats are numerous in the avenues within a mile or two of the mouth of the cave, and Mr. Mantell thinks he has secured at least two species. Several specimens are preserved in alcohol. It was not yet quite late enough in the season when we were at the cave, Oct. 16th–22d, for all the bats to be in winter quarters, as the season was very open and warm. Still in the galleries where they most abound, we found countless groups of them on the ceilings chippering and scolding for a foothold among each other. On one little patch of not over four by five inches, we counted forty bats, and were satisfied that one hundred and twenty at least were able to stand on a surface a foot square; for miles they are found in patches of various sizes, and a cursory glance satisfied us that it is quite safe to estimate them by millions. In these gloomy and silent regions where there is neither change of temperature nor difference of light to warn them of the revolving seasons, how do they know when to seek again the outer air when the winter is over and their long sleep is ended? Surely he who made them has not left them without a law for the government of their lives.

You may enquire what has formed the excavations of Mammoth Cave. I answer clearly and decidedly *water* and no other cause. No where else can we find such beautiful sculptured rocks as in Mammoth Cave; such *perfect* unequivocal and abundant proofs of the action of running water in corroding a soluble rock. The rough hewn block in the quarry, does not bear more distinct proof of the hammer and the chisel of the workman, than do the galleries of Mammoth Cave of the denuding and dissolving power of running water. At Niagara we see a vast chasm evidently cut by water for seven miles, and still in progress, but we cannot see beneath the cataract the water-worn surfaces, nor the rounded angles of the precipice—while the frosts and rains of countless winters, have reduced the walls of the chasm itself to a talus of crumbling and moss-grown rocks. But in the Mammoth Cave we see a freshness and perfection of surface, such as can be found only where the destructive agencies of meteoric causes are wholly absent, aided and quickened as those are on the upper surface by the processes of vegetable life, wholly unknown in the cave. Here we have the dry beds of subterranean rivers, exactly as they were left thousands of years ago by the stream which flowed through them when Niagara was young. No angle is less sharp, no groove or excavation less perfect than it was originally left, when the waters were suddenly drained off by cutting their way to some lower level. The very sand and rounded pebbles which pave the galleries now and formed the bed of the stream of old, have remained in many of the more distant galleries untrodden even by the foot of man. The rush of ideas

was strange and overpowering as I stood in one of these before unvisited avenues. in which the glow of a lamp had never before shone, and considered the complex chain of phenomenon which were before me. There were the delicate silicious forms of cyathophylla and encrinites, protruding from the softer limestone which had yielded to the dissolving power of the water; these carried me back to that vast and desolate ocean in which they flourished and were entombed as the crystalline matrix was slowly cast around them, mute chroniclers of a distant epoch. Then there were the long succeeding epochs of the upper secondary, and these past, the slow but resistless force of the contracting sphere elevated and drained the rocky beds of the ancient ocean: the action of meteorological causes commenced and the dissolving power of fresh water, following the almost invisible lines of structure in the rocks, began to hollow out these winding paths, slowly and yet surely. But I need not attempt to paint a picture in detail whose outlines in simple truth are so grand, and I must apologise for detaining you so long. I wish that all my scientific friends could visit the Mammoth Cave; it teaches many lessons in a manner not to be learned so well elsewhere, and in this respect I was most agreeably disappointed. I had heard that its interest was chiefly scenic; but I found it to exceed my utmost expectations as well in its illustrations of geological truth. as in the wonderful character of its features. I will not detain you with any attempts at descriptions of single parts, as no description can awaken those peculiar and deep emotions, which a personal study of its details is calculated to produce.

I know not how or where to stop, however, in my account of this interesting place. Excuse me if I trespass yet a little longer on your patience. In traversing the high vaulted galleries of the cave, our attention was occasionally arrested by the sound of falling water. We soon learned that in such cases we were in the vicinity of an entirely new feature in this subterranean region. Approaching cautiously to the spot from which the sound proceeds, we find usually a deep pit often surmounted by a dome. These pits are of various depths, but usually not less than one hundred feet, and cut down with walls of limestone so entirely vertical, that in many cases we were able to measure them from the edge with a line and plummet. When the gallery leads to the upper portion of one of these vertical excavations, it is called a *pit*; if on the other hand the approach is from beneath, it is usually called a *dome*, from the regular and arched appearance of the ceiling. These pits or domes are sometimes of almost incredible height, and I am satisfied that in one or two instances, they reach through the entire vertical thickness of all the strata composing the cave, or near three hundred feet. Such is Gorin's dome, one of the most remarkable features of the cave. Without seeing them you will

hardly credit and cannot appreciate the sharpness with which the vertical walls of this pit are moulded into architectural forms. At one point the outer diameter of the circle bounding it comes so close to one of the adjacent galleries, that the thin shell of interposed rock has been removed for a space two feet square through which as through a window, the observer may put his head and obtain an imperfect glimpse of the interior. You perceive that the loop-hole through which you look is midway between the ceiling and the first gallery below, and by a Bengal-light or other powerful illumination, a tolerable view is obtained of the vast proportions of this monolithic structure, built without hands. I was provided with the means of producing the Drummond light, and with the guide, my assistant and Mr. Mantell, we succeeded in making the perilous descent (where only by groping in the dark over profound chasms could we find a foothold) to a point some hundred feet below the opening above described. Here we erected the Drummond light, and by its aid obtained the first view of its lofty ceiling. The dome is of an irregular outline, in the main ovoidal, and from the ceiling hangs a great curtain of sculptured and vertically-grooved rock unsupported below, with the graceful outline and apparent lightness of actual drapery. A small stream of water falls from the top, which is broken into spray long before it reaches the bottom, and keeps the whole interior wet with its splashing. No gallery has been found which leads to the bottom of this most beautiful dome. We found other similar domes in which the pendant curtain just described had fallen, and portions of it but little removed from their original position, seemed poised to a second fall.

Of the mysterious rivers, with their many-tongued echoes—the mounds of mud and drift which they annually heap up,—the long miles of avenues which stretch away beyond them, rugged or smooth,—and of the vaulted ceilings, crystal grottos and gypsum coronets which tempt the mineralogist to untiring exploration, I must say nothing, for I have already gone too far in trespassing so much upon your kindness.

Art. XXXVII.—*Descriptions of new species of Fishes; from a "Synopsis of the Fishes of the Winnipisseogee and its connecting waters;"* by William Prescott, M.D. of Concord, N. H.

Read before the Association of American Geologists and Naturalists, at the meeting held in Boston, in Sept., 1847.

The Winnipisseogee and its tributaries, watering as they do a large portion of the interior of New Hampshire, embrace nearly all the species of fresh-water fishes existing in the state.

They consist of twenty-two species ranging through twelve genera, eight families and four orders, and all belong to that extensive and numerous group denominated *bony fishes.*

Among these are the following new species.

1. Salmo symmetrica. *Winnipisseogee Trout.*—There are many points of resemblance between this trout and the *Salmo confinis*, or lake trout of Dougherty, and the *Salmo amethystus* or Mackinaw trout of Kirtland, yet in many of its characteristic markings, it obviously differs from each. We observe *first* as to the form: while the Winnipisseogee *trout* is slender and symmetrical in form, a specimen measuring twenty inches in length, weighing but thirty ounces, and another of thirty-six inches but twelve and a half pounds;—the *lake trout*, as described and figured by DeKay, has a robust body and is comparatively *short* in proportion to its *weight;* a specimen measuring thirty-one inches weighing fifteen pounds.

Second, with regard to the number and arrangement of the teeth. According to DeKay the lake trout "has numerous curved teeth in the jaws with series of large teeth along the central furrow of the tongue and many series of acute teeth on the vomer and palatines." But the Winnipisseogee trout has no teeth in the central furrow of the tongue and but a single row on each of the other parts, and also on the pharyngeals.

Again, DeKay remarks that the first dorsal fin in his specimen, measuring thirty-one inches, "commenced *one* inch nearer the nose than the extremity of the caudal rays." In the Winnipisseogee trout of twenty inches in length it was *two* inches nearer the anterior extremity.

In February, 1846, previous to my having seen DeKay's report on the fishes of New York, a friend sent me a specimen of the Winnipisseogee trout, from which, at the time, I drew up the following description. *Weight* of specimen thirty ounces; *length* twenty inches; length of head four and a half inches. *Body* slender, subcylindrical. General appearance symmetrical. *Scales very* small. *Lateral line* waving the first inch, commencing a little below the superior posterior angle of the operculum and

gently descending the first half inch and ascending as much the next, when it proceeds in a straight line to the middle of the tail. *Head*, slightly flattened between the eyes. *Jaws* equal and pointed, the extremity of the *lower* received into a cavity in the *upper*, which at that place is destitute of teeth. Jaws, tongue, palatine and pharyngeals armed with a single row of small, pointed recurved teeth, which are much the largest, and less numerous in the lower jaws. Diameter of the eye half an inch; distance between the eyes one and eight-tenths inches; pupils black, irides golden.

Distance from the extremity of the jaws to the eye one and one-fifth inches; to the first dorsal fin, nine inches; to second dorsal, fourteen and a half inches; to ventrals, nine and a half inches. Length of base of first dorsal fin, where it unites with the body, two inches; or one-tenth of the length of the fish; height of the same, (longest rays,) two and a half inches; height of pectorals equal to that of the first dorsal; base and height of the ventrals, same as the anal, one and a half and two and a half inches. Caudal fin deeply forked, distance between extremities of bifurcation, four and a half inches, or equal to length of the head.

Color, light to dark brown on the back and upper part of head; sides, dark gray, above lateral line, lighter below; in some, approaching to light salmon; lower jaw, chin and abdomen, white, mottled with fuliginous; pectorals and ventrals gray, their anterior part being shaded faintly with pink. Dorsal and caudal fins dark gray.* The whole fish, including the dorsal and caudal fins, thickly sprinkled with small circular spots, of a drab color on the sides, olive on the back approaching to light salmon below. These spots become elongated and variously curved on the top of the head, and of an olive color, giving to the part a marbled appearance.

This trout is taken in great abundance by the hook through holes cut in the ice in winter, but not in such numbers as formerly. They are not unfrequently taken weighing twelve to fifteen pounds. The largest reported to have been taken weighed twenty-five pounds. By most persons it is highly esteemed, and it is generally considered an excellent fish for the table.

Genus COREGONUS, *Cuv.*—Wherever a large body of water exists in the northern portion of the United States or Canada, so far as investigation has been made, species of Coregonus have been found.

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* It is worthy of remark, that the color of this fish, in common with many others, is very much influenced by the nature of the bottom upon which it feeds, being uniformly much darker when frequenting muddy than gravelly bottoms, or rapid streams. The color varies also with age, and in many instances there is a marked difference between the color of the male and the female.

Two species inhabit the Winnipisseogee; and it is probable that they will be found also in Moose-head Lake, and perhaps in other large bodies of water in the state of Maine.

Upon carefully comparing those from the Winnipisseogee with the figures and descriptions of species from the great northern lakes, it is evident that they are new and undescribed species. It is hoped that the following description may lead to a more exact comparison.

The trivial names added, are those by which they are known and designated by the inhabitants of the surrounding country.

2. Coregonus Nov-Angliæ. *The Shad Waiter.*—*Body*, subcylindrical, eight and eight-tenths inches in length, greatest diameter one inch, greatest height one and four-tenths inches, (or nearly one-sixth part of the whole length,) tapering gradually to either extremity, from the point of its greatest height, which is at the anterior part of the first dorsal fin. *Scales*, medium, elongated laterally, with concentric striæ. *Lateral line* commences midway between the posterior and superior angles of the operculum, and proceeds in a straight line to the middle of the tail at the insertion of the caudal rays. *Head*, very small, conical, flattened between the eyes, length contained more than six times in the length of the body including the caudal fin. *Mouth*, small and destitute of teeth. Diameter of the eye three-tenths of an inch; distance between the eyes half an inch; pupils black, irides silvery. Distance from the extremity of snout to nostrils, equal to diameter of the eye; from the same to the eye, equal to the distance between the eyes.

The snout is truncated obliquely and shut over the lower jaw, which is shorter and inclosed within the intermaxillaries, which are short, wide, thin and truncated blades.

The first dorsal fin is three and three-tenths inches from the extremity of the snout, of a triangular form, base eight-tenths inch, height of longest ray one and one-tenth, of the shortest five-tenths of an inch; the anal is higher than long; the ventrals four, and the pectorals five times higher than long; the caudal is furcated, and the distance between the extremities one and two-tenths inches.

Color of the upper part of body and head dark olive, with bluish reflections; sides silvery; beneath, white; two-thirds of the anterior portion of the pectoral and anal fins reddish, the other third white; dorsals and caudal gray, anal white; operculum and preoperculum silvery with brilliant golden reflections.

There are about ninety scales in the direction of the lateral line which is very conspicuous, and about eight in a diagonal direction from the lateral line to the first dorsal, and ten from the same to the anal fin.

3. Coregonus Neo-Hantoniensis. *The Whiting.*—Length eighteen inches; weight two pounds; greatest diameter two inches, or one-ninth its length; greatest height three and seven-tenths inches, or the height in proportion to its length is about one to five; least height, in front of the caudal fin one and three-tenths inches. Body compressed; scales large. Lateral line commences at the superior angle of the operculum, and proceeds in a direct line to the middle of the tail. Head small, arched and conical, and its length is contained more than five and a half times in the whole length of the fish. Mouth small and toothless. Diameter of the eye half an inch; distance between the eyes one inch. Distance from extremity of jaws to the eye eight tenths of an inch; to first dorsal seven and two-tenths inches; to second do. thirteen inches; to pectoral three and two-tenths inches; to ventral same as first dorsal; to anal twelve inches.

Base of first dorsal equal to the diameter of the body, height of longest rays two and three-tenths inches, shortest six-tenths inch; height of pectorals four times their length; ventral three times higher than long; anal longer than high. Caudal deeply furcated, distance between extremities of bifurcation five inches.

Color: head and back, olive brown; sides lustrous and silvery, beneath white; dorsal fins brown, pectorals and ventrals white margined with brown; operculum silvery with golden reflections, exhibiting a brilliant play of colors; pupils black; irides metallic white.

Fin rays D, 10. P, 14. V, 12. A, 10. C, (?)

4. Lota brosmiana, *Storer.*—In the paper read before the Association this fish was referred to as a *Cusk.* This error arose from the circumstance that this fish is so called by the inhabitants about the Winnipisseogee, from its close resemblance to a cusk. I had not then seen Dr. Storer's description of it. The name in the west is *Eel Pout.*

In justice to Dr. Storer I substitute his description as published in the Boston Journal of Natural History, vol. iv, p. 58, instead of my own, with the remark, that as the specimens examined by us were very near equal in size, any difference of character may be considered worthy of note.

Dr. Storer's specimen measured twenty-seven inches and weighed five and a half pounds, mine measured twenty-seven and a half inches, and weighed five pounds; the greatest breadth or lateral diameter of his was five inches, of mine four inches; the greatest depth (height) of his was four and a half inches, of mine four inches.

In common with most of our fresh-water fishes, there is considerable difference in the color of the Lota. Whilst there are many fuliginous spots on those from the lake, there are few or

none on those taken from the river. These spots are, moreover, very irregular, generally being more numerous on one side of the fish than on the other.

All the specimens I have seen were beautifully reticulated on the back and top of the head, with brown, yellow and olive. In all other respects, the description of this fish by Dr. Storer, does not materially differ from the specimens I have examined.

I conclude by citing here Dr. Storer's description of the species.

"The specimen, which was a female, was twenty-seven inches in length; the length of the head was five and a half inches. The body is very broad in front of the dorsal fin; it becomes much depressed on the sides back of the first dorsal, and tapers to the caudal fin. Its general color is yellowish; the back, between the back of the head and the dorsal fin, exhibits a reddish tint; the top of the head and the opercula are fuliginous, the latter exhibiting golden reflections in their centre. The body beneath is white. The whole body is perfectly smooth, covered by innumerable cup-shaped depressions, like that of the *Zoarchus anguillaris*, and like that species it is lubricated by a viscid secretion.

"The depth of the body at the base of the pectorals is three and a half inches; its greatest depth is four and a half inches; its depth at the vent is three and a half inches. The greatest breadth of the head across the opercula is five inches. Its breadth across the eyes is three and a quarter inches. The snout is blunt. The top of the head is flat. The distance between the eyes is less than two inches. The eyes are circular, one half inch in diameter; the nostrils are double—the posterior, half an inch in front of the eyes; the anterior, which is tubular, and furnished with a cirrhus, two lines in length, is less than half an inch in front of this. The opercula are nearly two inches in length.

"The vertical gape of the mouth, is two inches in extent; the jaws are equal; the jaws, palatine bones and pharynx are armed with numerous fine teeth, placed like those of a card. The tongue large, smooth and white. Suspended from the chin is a cirrhus one and a half inches in length.

"The lateral line commences above the operculum, and gradually curving downwards, does not reach the middle of the body, until beyond the middle of the dorsal fin. The dorsal, pectoral, anal and caudal fins are colored as well as the sides of the fish, with bluish blotches, and are margined with black. The ventral fins are white beneath, and fuliginous above.

"The first dorsal fin is situated eleven inches back of the snout; it is two inches long, one inch high, the posterior portion being barely higher than the anterior. The second dorsal fin commences half an inch back of the preceding; it is less than an inch high at the commencement, and is half an inch high at

its posterior extremity. This fin is continued nearly to the base of the tail.

"The pectoral fins are situated directly behind and beneath the posterior angle of the operculum. They measure three and a half inches across when extended, and are rounded at their posterior extremity; they are an inch deep at their base.

"The ventral fins are situated in front of the pectorals, the rays are fleshy; the first ray is an inch long; the second ray is continued an inch beyond this; the remainder of the rays are shorter than the first ray.

"The anal fin commences half an inch back of the vent and terminates on a line with the second dorsal fin; the rays are of equal height throughout. The vent is large.

"The caudal fin is three and a half inches in length; when expanded, it is three and a half inches high, and rounded at its extremity.

"The weight of this specimen was five and a half pounds.

"B, 7. D, 10–71. P, 16. V, 6. A, 68. C, 34.

"In the esophagus of this fish I found a blade of grass, and the stomach contained numerous bones of a fish, too far digested to be determined; a large quantity of viscid mucus enveloped these bones. In the intestines were several pallets, apparently of soft mud."

ART. XXXVIII.—*Meteorological Observations: Abstract of a Meteorological Journal, kept at Beloit College, Beloit, Wisconsin, for the year* 1850, *Lat.* 42° 30′, *Long.* 12° *west of Washington; elevation above Lake Michigan,* 172 *feet—above the Ocean,* 750 *feet;* by S. PEARL LATHROP, M.D., Professor of Chemistry and Natural History.

Month.	BAROMETER.			THERMOMETER.			Rain and melted snow.	Prevailing winds.
	Max.	Min.	Mean.	Max.	Min.	Mean.		
January,	28·98	27·90	28·55	46	–3	25·33	2·59	S. & N. W.
February,	29·10	27·87	28·65	60	–7	27·50	·50	N. & N. W.
March,	28·99	28·09	28·58	59	8	31·50	2·82	N. & S.
April,	29·00	28·03	28·61	78	18	40·50	2·81	N. & N. E.
May,	28·98	28·27	28·64	87	25	54·25	1·10	N. & S.
June,	28·94	28·45	28·70	90	36	69·50	7·42	S. & S. W.
July,	28·77	28·38	28·61	92	58	74·10	7·15	S. & N. W.
August,	28·83	28·38	28·62	92	51	71·00	15·73	S. & S. E.
September,	28·92	28·41	28·64	84	38	59·72	2·58	N. & S.
October,	28·95	28·32	28·63	75	19	49·50	3·30	S. & N. W.
November,	29·12	28·20	28·66	68	12	39·50	3·30	S. & N. W.
December.	29·09	28·28	28·69	45	–4	24·00	1·94	N. & N. W.
Mean,			28·63			47·20	51·24 in.	

This being the first series of observations made at this place, no accurate comparisons, of course, can be made, in any respect,

with previous years. The past year, however, is regarded by those who have longest resided here, as one of usual temperature through the summer months, and somewhat warmer than common through the autumnal months and December. The temperature of the spring months, however, is thought to have been lower than it is generally.

The mean temperature of the spring months is 42°·08; of the summer months, 71°·50; and of the autumnal months, 49°·57.

The mean temperature for the year 1850 is 47°·20; which is very nearly the temperature of the wells of the houses on the bluff upon which the College is situated.

The density of the atmosphere, as indicated by the barometer, is thought to be too low. This instrument, (as were all the instruments used in making these observations,) was made by Mr. N. B. Chamberlain, Boston, but was somewhat injured in the transporting. It is estimated, from some comparisons which have been made, that its range is about ·50 inch too low.

It ought to be remarked, also, that the latitude and longitude, as well as the elevation of these observations, have not been definitely and strictly established by mathematical observations. They are regarded, however, as being not far from correct.

The observations have been made at the hours required by the Smithsonian Institution, viz.: sunrise, 9 A. M., 3 P. M., and 9 P. M.

The amount of rain and melted snow for the year is 51·24 inches, giving the large mean of 4·27 inches per month through the year. This amount is much greater than was to be anticipated, from the great number of fair days, and the small amount of falling weather, which is very noticeable by one accustomed to the clouds and mists of the Green Mountains. The remark concerning the West, so frequently heard at the East, that "it rains here only at night and on Sundays," has been rather wonderfully established during the past year, as a large portion of the rain has fallen in the night!

Another fact observed is, that frequently the circumstances, which in Vermont are almost invariably accompanied by rain or falling weather of some kind, here pass away with only a storm of wind of greater or less force. This may be owing to the clouds being dissipated and their moisture being absorbed by the great sweep of the winds over these extensive prairies. As two-thirds of the rain for the year fell in the three summer months, and one-third in one of these months, the remainder of the year may be regarded as having been rather dry.

The amount of snow which fell in the winter of 1849–50 was less than the usual quantity, being about four or five inches. There was some sleighing for three or four weeks. The quantity of snow, as appears from the observations of those longer resident here, varies greatly in different winters.

The year which has just past is considered as having been rather more productive than usual. Though the spring was uncommonly backward, yet the temperature was so uniform that no portion of vegetation was unduly brought forward and consequently injured by untimely frosts. Fruit, of the various kinds which have been introduced into this new country, did remarkably well, and gave a fair promise of the *fruit-full* years to come. It appears to me that this cannot be otherwise than a very favorable country, both on account of soil and climate, for growing fruit of most kinds, such as apples, peaches, grapes, &c.,—certainly so, if the last fall can be taken as a criterion of the character of future autumns.

The crops of grain, particularly of wheat and corn—the great staple productions of the southern portions of Wisconsin,—are fully equal to those of any previous year. Thousands of bushels of the finest wheat, however, were lost by the great rains of July and August. A large amount of wheat cut down, but not garnered, was never removed from the fields. The farmers, from the great ease of getting seed into the ground, have become too much accustomed to sow more than they can command help to harvest and suitably secure. Another great error is their delaying to garner what is already suitably cured for that purpose, before whole fields are cut down by their *reapers*. The crop of potatoes was good and scarcely at all injured by the "rot." The growth and ripening of all the species of Cucurbitaceæ was much favored by the constant warmth of the summer months, and, though the roots of the vines were somewhat injured by the rains of these months, yet the amount produced in most cases was very remarkable. As an instance, I would mention a case related to me by a near neighbor—Deacon Woodward—of forty-four ripe and twenty unripe pumpkins being grown, in his garden, upon the vine of one seed!

Another fact worthy of note was observed in the second flowering of several species of plants, as stated in the calendar, and the appearance of grasshoppers so late in the season as the 13th of November. Not having seen these myself, I am unable to say anything of the species, neither am I sure that this fact will be deemed uncommon by naturalists. The *Cantharis cinerea* appeared in the latter part of June in great numbers. They had been noticed here the two years previous. This year, in many gardens, they completely stripped the potatoe vines of their foliage. No particular injury, however, appeared to arise from this. They also seemed to take much pleasure in feeding upon white clover, which they destroyed in a short time. Their progress was from north to south. They were in such numbers that a half-bushel of them could have been gathered in a short time, with the appropriate means. The chinck-bug, *Lygæus leucopte-*

rus of Say, which made its appearance in some of the northern counties of Illinois, and was thought to have done great injury to the wheat crop, did not make its appearance, that I am aware of, in this state.*

There have been during the year several *heavy* storms accompanied with lightning, the most remarkable of which occurred on the 26th of April.

The atmosphere here is remarkably transparent, so much so, that the stars have an unwonted brilliancy and seem much nearer to you than in the northern portions of New England.

Another fact observed during the past year, is that of the "rotation" of the wind. The law of rotation, noticed by Dr. Dalton and more fully developed by Redfield and Dove, that the winds have a rotation from the north to the northeast, then east, southeast, and so through the points of the compass round to the north again, was sustained, with few exceptions. The number of circuits which have been made in this manner during the year, I am unable to state. Not thinking of this law of "rotation" of winds, until reminded of it by the fact here observed, proper care with respect to this point, was not had in the observations. In the absence of mountains to act as disturbing local causes, we may have here an opportunity of establishing or verifying this law in this country. Our strongest winds are those from the southwest; next to these the west and northwest. The wind very seldom blows for any length of time from the northeast or east.

Floral Calendar, &c.—Feb. 3d, the coldest day of the year. The average of the observations of the thermometer for the day being $-3^{\circ}\cdot 50$. At 4 o'clock, A. M., it stood at -24°.

March 22nd, Star of Bethlehem, crocus and snow-drop just coming up.

April 1st, Tulips and crown Imperial up; 4th, Soil in gardens sufficiently dry for working; 10th, Hepatica triloba and Ranunculus fascicularis in blossom; 15th, Pasque flower.

May 1st, Dutchman's Breeches, Squirrel corn, Adder's Tongue, Sanguinaria; 5th, Grapes begin to bloom; 11th, Geum vernum in flower; 14th, Missouri currant; 17th, Apple, Plum and Cherry; 20th, Flowering almond; 22nd, Tulips; 25th, Dodecatheon media.

June 5th, Common Syringa in blosson, Hypoxis erecta; 7th, Double Larkspur, Sweet William, Peonia; 12th, Green peas plenty; 14th, Garland Syringa in blossom, Strawberries ripe; 17th, Chinese Peonia and all kinds of Roses in blossom; 18th, Eschcholtzia in flower.

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* If any naturalists wish specimens of this insect, I shall take pleasure in furnishing them.

July 1st, Currants ripe; 5th, Raspberries ripe; 10th, Wheat harvest commences; 22nd, Gooseberries ripe; 25th, Dahlias and Gladiolus in flower; 27th, Harvest apple ripe; 25th and 27th, the hottest days of the year, the thermometer on each of these days averaging 82°; at 3 o'clock P. M., the thermometer stood at 92°.

August 5th, Blackberries ripe; 7th, Tiger flower in blossom; 10th, Pine apple melons ripe; 15th, Watermelons ripe; 19th, Garland Syringa—*Philadelphus grandiflorus*, in flower the second time; 25th, Snow-ball—*Virburnum opulus*, in flower the second time, Green gage ripe.

Sept. 2nd, Wild Plums ripe; 8th, Corn ripe and fit for harvesting; 20th, Isabella Grape ripe; 28th, Frost for the first time, Virburnum opulus in flower through this month.

Oct. 7th, Dahlias and Tomatoes injured by the frost for the first time. Virburnum opulus in bloom up to this date.

Nov. 16th, First snow; 22nd, Ranunculus fascicularis in blossom the second time and continued in bloom through this month.

Dec. 13th, The thermometer at sunrise stood −4°, the only time during the month that it was below zero.

ART. XXXIX.—*Miscellaneous Notices;* by J. W. BAILEY.

1. *On the real nature of the so-called "orifices" in Diatomaceous shells.*—It is well known to naturalists that several of the most distinguished writers on the Diatomaceæ have asserted the existence of "apertures," "orifices" or "mouths" in the ventral surfaces of many shells belonging to this family, and have even founded classes and genera upon the supposed presence of these openings. Some years ago I expressed in this Journal my disbelief in the existence of these apertures in the following words. "There are three rounded spaces on each of the ventral faces [of Naviculæ] which I think have been mistaken for openings but which appear to me to be thicker portions of the carapace."* This opinion was founded upon a careful observation of various fragments as seen in clean fossil specimens, and I still think that by the inspection of such fragments full evidence of the truth of my opinion may be obtained. I now offer proof of another kind which removes all doubt, and shows that these markings are neither apertures nor depressions, but are in reality the thickest parts of the shell. If the shells are placed in dilute hydrofluoric acid and watched by aid of the microscope as they gradually dissolve, the thinnest parts of course dissolve first, and apertures if any exist, should become enlarged. Now the very parts which

* See this Journal, vol. xlii, p. 97, American Bacillaria, part 2.

have been called orifices by some and depressions by others, are the last of all to disappear as the shell is dissolved. This mode of observation, beside establishing the fact that these are really the thickest parts of the shell, reveals many interesting particulars of structure in the various genera of Diatomaceæ. Thus in the large species of Pinnularia, it may be seen with even a low power, that the two parallel bands (separated by a canal) which reach from the central knob to the terminal ones, and which appear smooth before the application of the acid, become distinctly striated after their surface is dissolved off, as does also the central spot itself, showing that striæ which existed in the young shell are covered up and nearly obliterated by subsequent deposits.

In Stauroneis the cross-band and the two longitudinal bands are the last to dissolve, and these last bands, as in most of the family, appear separated by what is either a canal or a very thin portion of the shell. In Grammatophora the undulating lines are internal plates which are the last to dissolve. In Heliopelta, Actinoptychus, &c., the polygonal central spot is the last to disappear. In Isthmia, the spots on the surface, which at first appear like granular projections, are in reality thin portions of the shell, and under the action of the acid they soon become real holes. The acid also proves that the larger spots at the transverse bands are really a series of large arcuate holes in the siliceous shell, and the piers of this series of arches, remain some time after all the rest of the shell has vanished. Many other interesting facts are revealed by the action of this acid on these shells, and no one can use it without learning much with regard to their true structure.

A few directions with regard to the mode of manipulation in these experiments will probably be useful. As the fumes of the hydrofluoric acid, if they reached the lenses, would greatly injure them, I would advise experimenters (even if they have a micro-chemical stage) to protect the front face of their objectives by temporarily cementing to them a thin plate of mica by means of Canada balsam. This can be attached or removed in a few moments, and completely protects the lens without materially affecting its optical power. As mica resists the action of hydrofluoric acid much better than glass does, I prepare the cell in which the solution is to take place by cementing a bit of mica to a glass slide, and then cover all its surface except a central cell with wax. In this cell, the shells are put with a little water, and after adding a drop or two of the acid by means of a dropping rod of silver or platinum, the cell is covered with another plate of mica, and the action watched under the microscope.

2. *On the cell-membrane of Diatomaceous shells.*—If hydrofluoric acid is applied to recent Diatomaceæ, the silica soon dissolves leaving distinct, internal, flexible cell-membranes retaining

the general form of the shells. These may sometimes but not generally be detected even in the fossil specimens. When present, they materially interfere with the examination of the true nature of the markings of the siliceous shell, and should be destroyed by nitric acid and heat, before the hydrofluoric acid is employed, unless it is desired to study the cell-membrane itself. There is a curious difference in the action of hydrofluoric acid of the same strength upon specimens of fossil Diatomaceæ from different localities. Some dissolve with even too great rapidity in an acid which is slow and tedious in its action on other specimens. The Bermuda and Richmond Tripoli, and *some* specimens of fluviatile origin resist the action much longer than is usual with most specimens, whether they are recent marine, or either recent or fossil fluviatile ones. This difference is probably due to different degrees of hydration.

3. *Mode of distinguishing artificial from natural Camphor.*—By the application of polarized light the smallest portion of natural camphor may be distinguished from the artificial camphor (chlorohydrate of camphene). If small fragments of each be placed separately on glass slides, and a drop of alcohol added to each, they dissolve and speedily recrystallize. If the crystallization of the natural camphor is watched by means of the microscope and chromatic polarized light, a most beautiful display of *colored* crystals is seen, while with the artificial product nothing of the kind is witnessed.

4. *Infusoria in Hudson river Ice.*—For several years I have been in the habit of examining the mud upon the drift ice in the Hudson river, and as I find it constantly to present the same characters, I now announce the fact that it affords an abundant supply of fine specimens of marine siliceous Infusoria or Diatomaceæ. The mud upon this ice is probably in part scraped from the surface of the flats, and partly derived from the filtering of the muddy waters dashed upon its surface. Among the most common and most beautiful forms which are present, are Surirella splendida, *Ehr.*, Coscinodiscus subtilis, *Ehr.*, Triceratium favus, *Ehr.*, Biddulphia pulchella, *Gray*, Campylodiscus argus, *B.*, Cerataulus turgidus, *Ehr.*, Pinnularia, *B.*, &c., &c. The Coscinodiscus I have found in a living state as far up the river as Hyde Park. All these forms of course exist in the mud at the bottom of the river, but I have found the ice-mud to yield them most abundantly.

5. *On the detection of Sulphur.*—Dr. Playfair's beautiful salt, the nitro-prussid of soda, is justly recommended by its discoverer as the most delicate of all tests for alkaline sulphids [sulphurets].* An application of it which is very obvious although not alluded to by Dr. Playfair, is to employ it not only as a di-

* See L. E. and D. Phil. Mag., vol. xxxvi, p. 208.

rect test for alkaline sulphurets, but as an indirect one for sulphur in any of its compounds. Any substance containing sulphur will yield an alkaline sulphuret if heated with carbonate of soda, either with or without the addition of carbonaceous matter according as a deoxydizing action is or is not required. The magnificent purple which is then produced by the addition of the fused mass to a drop of the solution of the nitro-prussid will at once prove the presence of sulphur. This reaction is so easily obtained and is so decisive that the nitro-prussid of soda must take its place among the most useful adjuncts to the blowpipe tests. By means of it the presence of sulphur in the smallest particles of coagulated albumen, horn, nails, feathers, mustard seed, &c., which can be conveniently supported on a platinum wire for blowpipe experiment, may be most distinctly shown, and I have repeatedly obtained the characteristic purple tint in operating upon a piece of a single fibre of the human hair *less than an inch in length.*

ART. XL.—*On the Chemical Constitution of the Mineral, Warwickite;* by T. S. HUNT, of the Geological Commission of Canada.

THIS mineral, which had been for several years known to collectors under the name of *hypersthene*, was first proposed as a new species by Prof. C. U. Shepard in 1838;* in the following year he added some farther experiments upon its chemical constitution and deduced from them the conclusion that it was a difluorid of titanium and iron with traces of yttria.*

It occurs generally in very small and slender crystals having their edges rounded, but occasionally, as described by Shepard, in larger crystals, rarely half an inch in diameter, which are however much softer than the smaller crystals, and possess in a less degree the characteristic lustre of the cleavage planes. In February, 1846, while a student in the Laboratory of Yale College, I submitted to analysis one of these larger crystals, having a hardness a little more than 3, and the specific gravity 3·188. The examination showed the presence of titanic and silicic acids, with magnesia, alumina, protoxyd of iron, water, and a small portion of lime. A quantitative analysis gave their respective proportions as follows. Silica, 18·5, titanic acid, 28·2. protoxyd of iron, 10·59, magnesia, 22·2, alumina, 13·84, lime, 1·3, and water, 7·3 = 101·98.

The composition of this mineral differed so much from that assigned to Warwickite by Prof. Shepard, that I described it as a

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* This Journal, vol. xxxiv, p. 313, and vol. xxxvi, p. 85.

new species under the name of *Enceladite.** As however the limestone in which it occurs, often contains altered and hydrated minerals, such as the well known steatitic spinels and pyroxenes, I suggested that it was itself not improbably an altered mineral, a conjecture which derived additional support from the fact that a spinel in contact with one of the crystals of Enceladite, was in part converted into a soft substance resembling serpentine. I determined therefore to examine the small hard and brilliant crystals of Warwickite which in form and cleavage so much resemble the Enceladite.

The specimen containing them was from the original locality in the vicinity of Edenville, Orange county, New York, and consisted of a white crystalline limestone enclosing small brilliant octahedrons of translucent greenish spinel, and crystalline grains of brownish or greenish yellow chondrodite, with occasional grains of serpentine. The crystals of Warwickite, which penetrate in every direction the cleavable calcareous spar, are very small, the largest being scarcely half a line in diameter, and not more than three or four in length. Their characters correspond perfectly with the description of Shepard; they are oblique rhombic prisms, but rounded both on their lateral and terminal edges, so that it is impossible to measure them; the macrodiagonal cleavage is perfect and exhibits in a high degree that metallic lustre and copper-red reflection which formerly obtained for the mineral the name of hypersthene. The exterior of the crystals is brownish black with a vitreous lustre; the surface is broken by markings or rifts, oblique to the prism and apparently corresponding to the oblique cross cleavage, observed upon the lateral cleavage planes. The surface of the crystals has a hardness of 6, (Shepard,) while that of the cleavage planes is somewhat less. When exposed to the weather, the mineral becomes soft, pulverulent and of an ochre-yellow, still however retaining the characteristic cleavage.

By the action of dilute hydrochloric acid, which does not act upon the crystals, a portion of them were freed from their gangue, and they were afterwards carefully picked out from the foreign minerals. The whole weight of the crystals which I was thus able to command was but about five decigrammes. They were first employed for a determination of the specific gravity. and after having been carefully boiled in water, to expel any airbubbles, gave the number 2·89.

The mineral was finely pulverized and the powder dried over sulphuric acid at the ordinary temperature; its color was dark purplish brown, exhibiting until the mineral was very finely divided, the coppery reflection of the cleavage surfaces.

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* This Journal, 2nd Series, vol. ii, p. 31.

A. ·250 grammes of the powder were intensely ignited for some minutes in a platinum crucible; the loss of weight was ·004, and the color became of a lighter reddish brown. Sulphuric acid diluted with its bulk of water was now added, and the crucible being covered with a watch-glass, heat was applied until vapors of the sulphuric acid began to be evolved. The polish of the glass was not affected, showing the absence of fluorine. Another trial with concentrated acid upon a portion of the mineral before ignition, gave the same negative result. By a prolonged digestion with the acid, the whole was converted into a white mass, which was completely soluble in warm water, evincing the absence of silica.

B. The recent solution prepared in a carefully covered crucible, gave with ferrocyanid of potassium a pale greenish-blue precipitate, but with the ferridcyanid an immediate precipitate of a dark blue showing that iron was present as a protosalt. It was not affected by sulphuretted hydrogen.

C. The solution being largely diluted was boiled, when it threw down a large quantity of titanic acid. This being separated by a filter, and a few drops of nitric acid having been added to the boiling liquid, it was precipitated with a slight excess of caustic ammonia. The precipitate was reddish brown and gelatinous; it was washed and digested with heat, for some time, in a solution of caustic potash; the alkaline liquid, acidulated with hydrochloric acid, gave with ammonia only a few imponderable flocculi. Alumina is therefore absent.

D. The ammoniacal precipitate was then digested for some hours with a concentrated solution of carbonate of ammonia. It became darker and a portion was evidently dissolved; after filtration the ammoniacal solution was acidulated with hydrochloric acid, boiled, and ammonia added; the transparency of the liquid was disturbed only by the separation of a trace of precipitate too small to be estimated; this was regarded as titanic acid which is not wholly insoluble in carbonate of ammonia The ammoniacal solution gave with phosphate of soda a precipitate of ammonio-phosphate of magnesia.

E. The insoluble residue from the last, having been dissolved by a drop or two of dilute sulphuric acid and, boiled, yielded a small additional quantity of titanic acid, and the filtrate precipitated by ammonia gave a substance having the appearance of pure peroxyd of iron. Its nature was verified by redissolving it, adding tartaric acid and ammonia in excess, and precipitating the metal as sulphuret.

F. The ammoniacal filtrate from C was not affected by hydrosulphuret or oxalate of ammonia, but gave by the addition of phosphate of soda a copious precipitate of phosphate of magnesia and ammonia. A portion of the solution evaporated to dryness and ignited to expel ammoniacal salts, was precipitated by

baryta, and the filtrate examined for alkalies without success. A portion of the original sulphuric solution was tested for phosphoric acid by molybdate of ammonia, but gave no indication of its presence.

From these experiments it appears that the only ingredients present in the mineral are titanic acid and magnesia, with some protoxyd of iron. There remained at my disposal only ·200 grammes of the mineral, and with this, I endeavored to ascertain the relative proportions of the constituents. It lost by intense ignition ·004 grammes, and was then decomposed as before by sulphuric acid, and dissolved in a large quantity of water, from which by boiling the greater part of the titanic acid was thrown down. Having peroxydized the iron, and added a portion of sal-ammoniac, the solution was precipitated by ammonia; the well washed precipitate having been dissolved in hydrochloric acid, a solution of bicarbonate of potash was gradually added to excess, and the ferruginous precipitate having been collected, was redissolved in hydrochloric acid, precipitated by ammonia, dried and ignited. It weighed ·022 grammes, and when analyzed after the plan described under E, gave ·018 of pure peroxyd of iron equal to ·0162 of protoxyd. The difference of ·004 grammes was considered as titanic acid, and was added to that originally precipitated, making in all ·063 grammes.

The magnesia in the first ammoniacal filtrate, and that in the solution with bicarbonate of potash, were precipitated as ammonio-phosphate which after ignition weighed ·237 grammes = ·087 of magnesia.

An accidental loss was sustained upon the original solution of the mineral, but I was obliged to complete the analysis upon that portion, for want of material; it is believed that the numbers above given, represent the respective proportions of the several constituents, and that the deficiency in their sum is no more than corresponds to the loss. We have from ·200 grammes,

Titanic acid,	·0630	=	31·5
Magnesia,	·0870	=	43·5
Protoxyd of iron,	·0162	=	8·1
Loss on ignition,	·0040	=	2·0
	·1702		85·1

If we take the deficiency of about fifteen per cent. to represent only the three ingredients above found, we have by calculation the following as the composition of the mineral.

Titanic acid,	37·14	containing oxygen,	14·82
Magnesia,	51·30	"	20·55
Protoxyd of iron,	9·55	"	2·11
Loss on ign., (water?)	2·00	"	1·72
	99·99.		

If the volatile matter be regarded as not essential to the composition of the mineral, we have as the ratio of the oxygen of the titanic acid to that of the bases, 14·82 : 22·66, or very nearly 2 : 3, which leads to the formula $Ti O_2$, 3(Mg O, Fe O). or, $Ti_2 O_5$ (M_6) in the notation of Gerhardt, or a trititanate of magnesia in which a small portion of the base is replaced by protoxyd of iron.

This interesting mineral adds another to the small number of simple titanates already known, and pertains to a different chemical type from either Perowskite or Polymignite. The Enceladite which I formerly proposed as a new species, is undoubtedly nothing more than Warwickite, altered by a process similar to that which has converted the associated spinels into steatite, the introduction of silica and water.

It might be a question whether the alumina were introduced with these ingredients, or whether in the original mineral it replaced in part the magnesia of the larger crystals, which also contain a larger proportion of iron. It is however to be remarked in the first place that as far as examined, steatitic pseudomorphs do not appear to contain alumina, unless it has been an original ingredient in the composition of the mineral; and secondly, that excluding the silica and water, the ratio between the oxygen of the titanic acid, and that of the magnesia, protoxyd of iron and alumina in the Enceladite is very nearly 2 : 3, as in the Warwickite. I am therefore inclined to regard, the alumina as Al^3 (Gerhardt) as replacing in part the magnesia of the larger crystals. The analysis of some of these in an unaltered condition would be very desirable to settle the question.

I avail myself of this occasion to correct an error which occurs in the "Annual Report of the Progress of Chemistry" for 1847–48, by Profs. Liebig and Kopp. In citing my description of the Enceladite, they state that I regard the mineral as an altered titanic iron.* The compiler has however failed to apprehend my meaning; in suggesting its probable metamorphic origin, I remarked that the form of the crystal was inconsistent with the idea that it could be derived from a titanic iron by the introduction of a silicate of magnesia and water.† I had not at that time the present results to guide me in forming a notion of the real nature of the metamorphic action.‡

Montreal, C. E., March 12th, 1851.

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* English Edition, vol. ii, p. 428. † This Journal, 2nd Series, vol. ii, p. 36.

‡ In the analysis of the Enceladite, the opinion was advanced that the titanium existed in the mineral as titanic oxyd, $Ti_2 O_3$. M. Rammelsberg however (Handw. 3d Sup. 41) inclines to the view that it exists as titanic acid, an opinion which to-day I am not disposed to dispute, although I may remark that whatever value may be attached to the reaction which I then adduced in favor of the idea,—(the blue color fading into white on exposure to the air, which was produced on heating the mineral with concentrated sulphuric acid,)—it was adduced independently of me about the same time by Scheerer in support of his view of the existence of titanic oxyd in the titanic iron of Hitteroë. (Annalen der Physik und Chemie, t. lxiv, p. 489.)

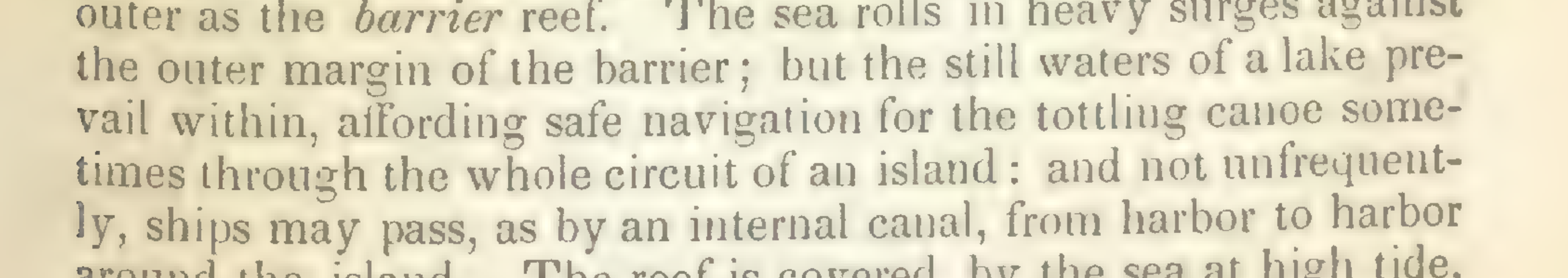
Art. XLI.—*On Coral Reefs and Islands*; by James D. Dana.—Part I.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U.S.N.

1. General Features of Coral Reefs and Islands.

The general features of reefs and coral islands have often been delineated by travellers, and are probably almost as familiar to the reader as the scenes of the land around us. Yet a few brief remarks on this point form a necessary introduction to the more minute descriptions of structure which follow.

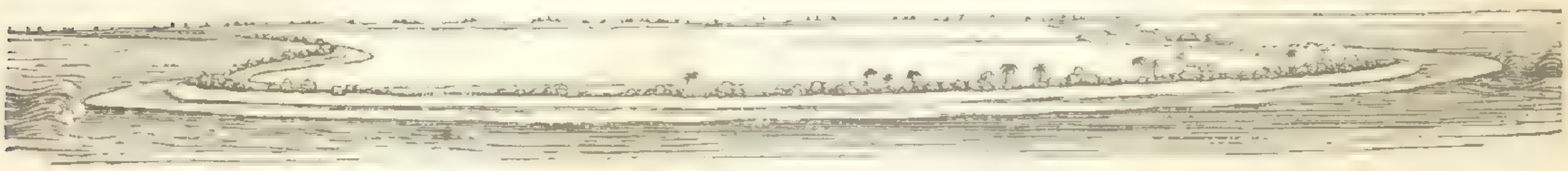
Coral reefs.—A wide platform of rock covered with the sea except at low tide, borders most of the high islands of the Pacific. It is a vast accumulation of coral, based upon the bottom in the shallow waters of the shores. This bank or table of coral rock, is of varying width, from a few hundred feet to a mile or more; and although the surface is usually nearly flat, it is often intersected by irregular boat channels, or occasionally encloses large bays, affording harbor protection to scores of ships. In very many instances the reef stands at a distance from the shores like an artificial mole, leaving a wide and deep channel between it and the land; and within this channel are other coral reefs, some in scattered patches and others attached to the shore. The inner reef in these cases, is distinguished as the *fringing* reef, and the outer as the *barrier* reef. The sea rolls in heavy surges against the outer margin of the barrier; but the still waters of a lake prevail within, affording safe navigation for the tottling canoe sometimes through the whole circuit of an island: and not unfrequently, ships may pass, as by an internal canal, from harbor to harbor around the island. The reef is covered by the sea at high tide, yet the smoother waters indicate its extent, and a line of breakers its outline. Occasionally a green island rises from the reef, and in some instances, a grove of palms stretches along the barrier for miles, where the action of the sea has raised the coral structure above the waves.



The sketch annexed conveys some idea of the peculiar features presented by a Pacific island and its encircling reefs, though in order to fill out the scene, the jagged heights and deep gorges of the islands should be covered with forests and the shores with groves and native villages. The coral platform which borders the

shore is represented with its usual uneven line,—its broad harbors with a narrow entrance,—and to the left an irregular ship channel running between the inner or fringing reef, and the outer or barrier. At a single place the sea is faced by a cliff; and here owing to the boldness of the shores and depth of waters, the reef is wanting. To the right there is only a fringing reef.

Coral islands.—Coral islands resemble the reefs just described, except that a lake or lagoon is incircled instead of a mountainous island. A narrow rim of coral reef, generally but a few hundred



yards wide, stretches around the enclosed waters. In some parts it is so low that the waves are still dashing over it into the lagoon; and in others it is still verdant with the rich foliage of the tropics. The coral-made land when highest is seldom elevated over eight or ten feet above high tide.

When first seen from the deck of a vessel, only a series of dark points is descried just above the horizon. Shortly after, the points enlarge into the plumed tops of cocoa-nut trees, and a line of green, interrupted at intervals, is traced along the water's surface. Approaching still nearer, the lake and its belt of verdure are spread out before the eye, and a scene of more interest can scarcely be imagined. The surf beating loud and heavy along the margin of the reef, presents a strange contrast to the prospect beyond,—the white coral beach, the massy foliage of the grove, and the embosomed lake with its tiny islets. The color of the lagoon water is often as blue as the ocean, although but fifteen or twenty fathoms deep; yet shades of green and yellow are intermingled, where patches of sand or coral-knolls are near the surface; and the green is a delicate apple-shade, quite unlike the usual muddy tint of shallow waters.

The belt of verdure, though sometimes continuous around the lagoon is usually broken in some parts into islets which are separated by varying intervals of bare reef; and through one or more of these intervals, a ship-channel occasionally opens into the lagoon. The larger coral islands are thus a string of islands arranged along a line of coral reef. The king of the Maldives bears the high-sounding title of "Ibrahim Sultan King of the thirteen Atollons and Twelve Thousand Isles;" which Capt. W. F. W. Owen, R. N., remarks, is no exaggeration.

The usual features of these islands are presented in the above sketch. The narrow belt is seen to consist of several patches of vegetation; and within are the quiet waters which offer a retreat for vessels whenever there is an opening to the lagoon.

A few small coral islands are simple reefs without lagoons. In some cases they are bare banks of coral; but generally, the usual vegetation of the islands has obtained a foothold, and affords some protection against the glare of the coral sand.

With these general remarks we may enter upon the more particular consideration of the characters of reefs and islands.

2. Characters of Fringing and Barrier Reefs.

a. General features.

Fringing reefs have been described as those that directly adjoin the shores of an island; and the *barrier*, as the exterior reefs, separated from the fringing reef, or from the shores when there is no inner reef, by an open channel.

While there are only narrow shore-reefs to many islands, around others, a distant barrier extends like an artificial mole, sometimes ten or even fifteen miles from the land, and enclosing not only one, but at times several islands. Between the narrow fringing platform and these remote barriers, there is every possible variation as to extent and relative position. The inner channel is sometimes barely deep enough at low tide for canoes, or for long distances may be wanting entirely. Then again, it is a narrow intricate passage, obstructed by knolls or patches of coral, rendering the navigation quite dangerous. Again, it is for miles in length an open sea, in which ships find room to beat against a head wind with a depth of twenty, thirty, or even fifty fathoms. Yet hidden reefs make caution necessary. Patches from a few square feet to many square miles in extent are met with over the broad area enclosed by these distant barriers.

These varieties of form and position are well exemplified in a single group of islands—the Feejees; and we would refer the reader to a reduced copy of the admirable chart of this Archipelago by the Expedition.*

Near the middle of the chart is the island *Goro;* its shores, excepting the western, are bordered by a fringing reef. The island *Angau*, south of Goro, is encircled by a coral breakwater, which on the southern and western sides runs far from the shores, and is a proper barrier reef, while on the eastern side, the same reef is attached to the coast and is a fringing reef. From these examples it is perceived that there is no proper distinction as regards mode of formation between barrier and fringing reefs. It is also apparent that while a reef is sometimes quite encircling, in other instances it is interrupted along certain shores, or may be wanting along a large part of a line of coast; and occasionally the reef may be confined to a single point of an island.

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* For this chart, see Capt. Wilkes's Narrative of the Exploring Expedition, or the Geological Report of the writer.

Above Angau lies *Nairai;* though a smaller island than Angau the barrier reef is of greater extent, and stretches off far from the shores. To the eastward of Nairai are *Vatu Rera*, *Chichia*, and *Naiau*, other examples of islands fringed around with narrow reefs. *Lakemba*, a little more to the southward, is also encircled with coral: but on the east side the reef is a distant barrier. In *Aiva*, immediately south of Lakemba, the same structure is exemplified; but the coral ring is singularly large for the little spots of land it encloses. The *Argo Reef*, east of Lakemba, is a still larger barrier, encircling two points of rock called Bacon's isles. It is actually a large lagoon island, twenty miles long, with some coral islets in the lagoon, and two of basaltic constitution, the largest of which is only a mile in diameter. Aiva and Lakemba are in fact other lagoon islands, in which the rocky islands of the interior bear a larger proportion to the whole area. The same view is farther illustrated by comparing the Argo reef with Nairai, Angau, or Moala: the only difference in these cases consists in the greater distance of the reef from the shores which it encircles, and the smaller extent of the enclosed land.

Passing to the large islands *Vanua Levu* and *Viti Levu*, we observe the same peculiarities illustrated on a much grander scale. Along the southern shores of Viti Levu, the coral reef lies close against the coast; and the same is seen on the east side and north extremity of Vanua Levu. But on the west side of these islands, this reef stretches far off from the land, and in some parts is even twenty-five miles distant, with a broad sea within. This sea, however, is obstructed by reefs, and besides, along the shores there are proper fringing reefs.

The forms of encircling reefs depend evidently to a great extent on that of the land they enclose. That this is the case even in the Argo reef and such other examples as offer now but a single rock above the surface of the enclosed lagoon, we shall endeavor to make apparent, if not already so, when the cause of the forms of coral islands is under discussion. Yet it is also evident that this correspondence is not exact, for many parts of the shores, and sometimes more than half the coast, may be exposed to the sea, while other portions are protected by a wide barrier.

In recapitulation, we remark, that reefs around islands may be (1) entirely encircling; or they may be (2) confined to a larger or a smaller portion of the coast, either continuous or interrupted: they may (3) constitute throughout a distant barrier; or (4) the reef may be fringing in one part and a barrier in another; or (5) it may be fringing alone: the barrier may be (6) at great distances from the shores, with a wide sea within, or (7) it may so unite to the fringing reef that the channel between will hardly float a canoe. These points are fully sustained by all reef regions.

A wide difference in the extent of reefs would be inferred from these facts. There is the mere point of coral rock; and again, as for example, west of the two large Feejee islands, there may be three thousand square miles of continuous reef-ground, occupied with coral patches and intermediate channels or seas. The enclosing barrier off Vanua Levu alone is more than one hundred miles long. The Exploring Isles, in the eastern part of the Feejee group, have a barrier eighty miles in circuit. New Caledonia, as often cited, has a reef along its whole western shores, a distance of two hundred and fifty miles, and it extends one hundred and fifty miles farther north, adding this much to the length of the island. The great Australian barrier forms a broken line, a thousand miles in length, lying off the coast from the Northern Cape to the tropical circle; and the channel within is in some parts sixty miles from the coast, with a depth of thirty to sixty fathoms.

The seas outside of the lines of coral reef are often unfathomable within a short distance of the line of breakers.

b. Structure of Reef Formations.

In the description of reef grounds or reef-formations there are several distinct subjects for consideration, as is obvious from the preceding remarks. These are—

1. *Outer reefs*, or reefs formed from the growth of corals exposed to the open seas. Of this character, are all proper barrier reefs, and such fringing reefs as are unprotected by a barrier.

2. *Inner reefs*, or reefs formed in quiet water between a barrier and the shores of an island.

3. *Channels* or *seas within barriers*, which may receive detritus either from the reefs, or the shores, or from both of these sources combined.

4. *Beaches and beach formations*, produced by coral accumulations on the shores through the action of the sea and winds.

The outer and inner reefs, channels, and beaches, act each their part in producing the coral formations in progress about islands.

Outer reefs.—The outer reefs or flats of coral rock receive the waves along their margin; and the outline exposed to this action is very much cut up with deep channels which give passage to the advancing waters, and to the currents that flow back in preparation for the next breaker. This margin, which we have said rises but little above low-tide level, usually slopes beneath the water at an angle of forty to seventy degrees to a depth of three to eight fathoms; thence the waters deepen very gradually for one to five hundred yards out, and from this there is finally an abrupt descent, generally by an angle of at least forty degrees to depths beyond the reach of a sounding lead. There is a great difference in the rapidity with which the water deepens, as might

be inferred from the varied character of submarine slopes; in some cases the shallow waters may extend for two or three miles beyond the reef, but it is far more common to meet with the opposite extreme—unfathomable depths within a few hundred feet.

The growing corals are mostly confined to the shallow waters of the reef, and to its sloping margin up which they extend to within a foot or less of the surface. In these shallow waters the various zoophytes at times are crowded over extensive areas; yet very often they occur only in patches scattered throughout large fields of coral debris. The top of the reef is mostly destitute of life, and consists of the naked coral rock, more or less covered with coral sand. Yet there are some shallow pools, especially towards the outer limits, which abound in corals.

The exposed edge of the reef is commonly raised a few inches above the general surface, and is, therefore, the first part laid bare by the retreating tide, although a dangerous place for a ramble, on account of the heavy breakers. Though very uneven, the surface has generally a smooth, water-worn appearance, and is spotted with various shades of pink and purple. These colors, as observed by Chamisso, are due to incrusting Nullipores, that grow like lichens over the rock: they are vegetable in nature, though composed mostly of lime. Other nodular and branching Nullipores, some sprigs of Madrepores, and a few of Astræas grow in the more sheltered cavities, where they are not easily dislodged by the waves; and among them, despite the breakers, cling numerous echini, asterias, and actiniæ. The gradual wear of the reefs by the wash of the sea is prevented, to a great extent, by these Nullipore incrustations, as was pointed out by Darwin.* He states that on Keeling's Island they constitute a layer two or three feet in thickness, with a breadth of twenty feet. They are abundant on the Paumotu reefs.

The outer reefs are distinguished in many parts from the inner by becoming covered with accumulations of coral fragments and sand, which are thrown up by the waves: finding a lodgment some distance back from the margin of the reef, the accumulations gradually increase, till in many instances they form dry land, and prepare the way for vegetation. Such effects are mostly confined, however, to the sides open to the prevailing wind, and are generally of limited extent. Occasionally, as at Bolabola, the reef for miles in length is changed from the submerged coral bank into a habitable islet—a green belt to the island of rocks and forests within. The causes and the result are much the same as in the case of the lagoon island, and the steps in the process will be more particularly described when treating of the coral atoll.

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* Darwin on Coral Reefs, London, 1842, page 9, and elsewhere.

The rock of the reef, wherever broken, exhibits a compact texture. In some parts it consists of coral fragments of quite large size firmly cemented: other portions are a finer coral breccia, or conglomerate: and still others, more common, are solid white limestones, as impalpable and homogeneous in texture as the secondary limestone of our continents, and usually much harder. It is rare to meet with any corals in this reef-rock retaining the original position of growth. It is at once apparent that the rock consists of the debris of the coral fields, consolidated by a calcareous cement; and the great abundance of the finer variety of rock indicates that much of it has originated from coral sand or mud. Wherever broken, it is found to present the same character as here described, a texture indicating a detritus origin. This reef-rock is formed in the midst of the waves; and we shall hereafter show that to this fact it owes many of its peculiarities. Besides corals, the shells of the seas contribute to it, and it sometimes contains them as fossils, along with bones of fish, exuviæ of crabs, spines and fragments of echini, and other remains of organic life inhabiting reef-grounds.

Inner reefs.—In the still waters of the inner channels or lagoons, when of large extent, we find corals growing in their greatest perfection, and the richest views are presented to the explorer of coral scenery. There are many regions—in the Feejes, examples are common—where a remote barrier encloses as pure a sea as the ocean beyond; and the greatest agitation is only such as the wind may excite on a narrow lake or channel. This condition gives rise to some important peculiarities of structure in the inner reefs.

In the general appearance of the surface, however, they much resemble the outer reefs. They are nearly flat, and though mostly bare of life, and much covered with coral sand, there are seldom any large accumulations of coral debris. The margin is generally less abrupt; yet there is every variety, from the gradually sloping bed of corals to the bluff declivity with its clinging clumps. In different parts, there are many portions still under water at the lowest tides; and here, (as well as upon the outer banks,) fine fishing sport is afforded the natives, who wade out at ebb tide with spears, pronged sticks, and nets, to supply themselves with food. The lover of the marvellous may find abundant gratification by joining in such a ramble; among coral plants and flowers, with fishes of fantastic colors, starfish, echini, and myriads of other beings which science alone has named, fit inhabitants of a coral world, there is on every side occasion for surprise and admiration.

Between the large reefs, which spread a broad surface at the water's edge of lifeless coral rock, sometimes of great extent, there are other patches, still submerged, which are covered with growing corals throughout. They are of different elevations; and though at times but a few yards in breadth, there is often along-

side of them a depth of many fathoms. They sometimes seem to grow up from a narrow base, like a mushroom; and a ship striking one with her keel may crush it and glide on. More frequently, they are below like the solid reef above described, and the contest is more likely to be fatal to the vessel than to the coral patch. Corals grow over them, as in the shallow waters about other reefs; and, as elsewhere, there are deep cavities among the congregated corals, in which a lead will sometimes sink to a depth of several feet, or even fathoms. These holes about growing reefs often give much annoyance to the boat which may venture to anchor upon them; and in many an instance in the course of the surveys, diving was the only resource left for freeing the foul anchor.

The rock of the inner reefs is peculiar in being but sparingly fragmentary. The corals composing it stand to a great extent as they grew; yet it is not less compact or firm in its texture than the rock of the outer reefs. The cavities among the branches and growing masses gradually become filled with coral sand, and the whole is finally cemented and thoroughly compacted. At Tongatabu and among the Feejee Islands, reefs thus made of corals standing in their growing positions are common. Though now mere dead rock, the limits of the several constituent coral masses may be distinctly made out. Some individual specimens of Porites in the rock of the inner reef of Tongatabu were twenty-five feet in diameter; and Astræas and Meandrinas, both there and in the Feejees, measured twelve to fifteen feet. These corals, when growing beneath the water, form solid hemispheres, or rounded hillocks; but on reaching the surface, the top dies, and enlargement takes place only on the sides. In this manner the hemisphere is finally changed to a broad cylinder with a flat top. This was the condition of the Astræas and Porites in the reef-rock referred to. The platform looks like a Cyclopean pavement, except that the cementing material, filling in between the huge masses, is more solid than any work of art: it even exceeds in compactness the corals themselves. Other portions of these reefs consist of *branching* corals, with the intervals filled in by sand and small fragments; for even in the more still waters fragments are to some extent produced.* There is also to be found here, and frequently over large areas, the solid white limestone already described, showing internally no evidence of its coral origin, and containing rarely a few shells or imbedded fossils.

The formation of the inner reefs goes on at a less rapid rate than that of the outer, as the process depends on growth unaided, except in a comparatively small degree, by the action of the waves. Moreover, as we shall explain more particularly in another place,

* A rock of this kind is often used for buildings and for walls on the island of Oahu. It consists mainly of Porites, and in many parts is still cavernous, or but imperfectly cemented. It is the material of the large church at Honolulu.

impure or fresh waters and currents often operate to retard their growth.

Owing to the last mentioned cause, the inner reefs are not usually joined close to the beach. They stand off a little, separated by an interval of shallow water. At Mathuata, in the Feejees, however, the reef extends quite up; and it is the more remarkable as the country is a plain, the site of a Feejee village, and a mile or two back stands a high bluff. On an island off this part of Vanua Lebu is another example of this fact, and many more might be cited. In such cases, however, there is evidence that the shores upon which the corals grew were bare rocks, instead of moving beach-sands.

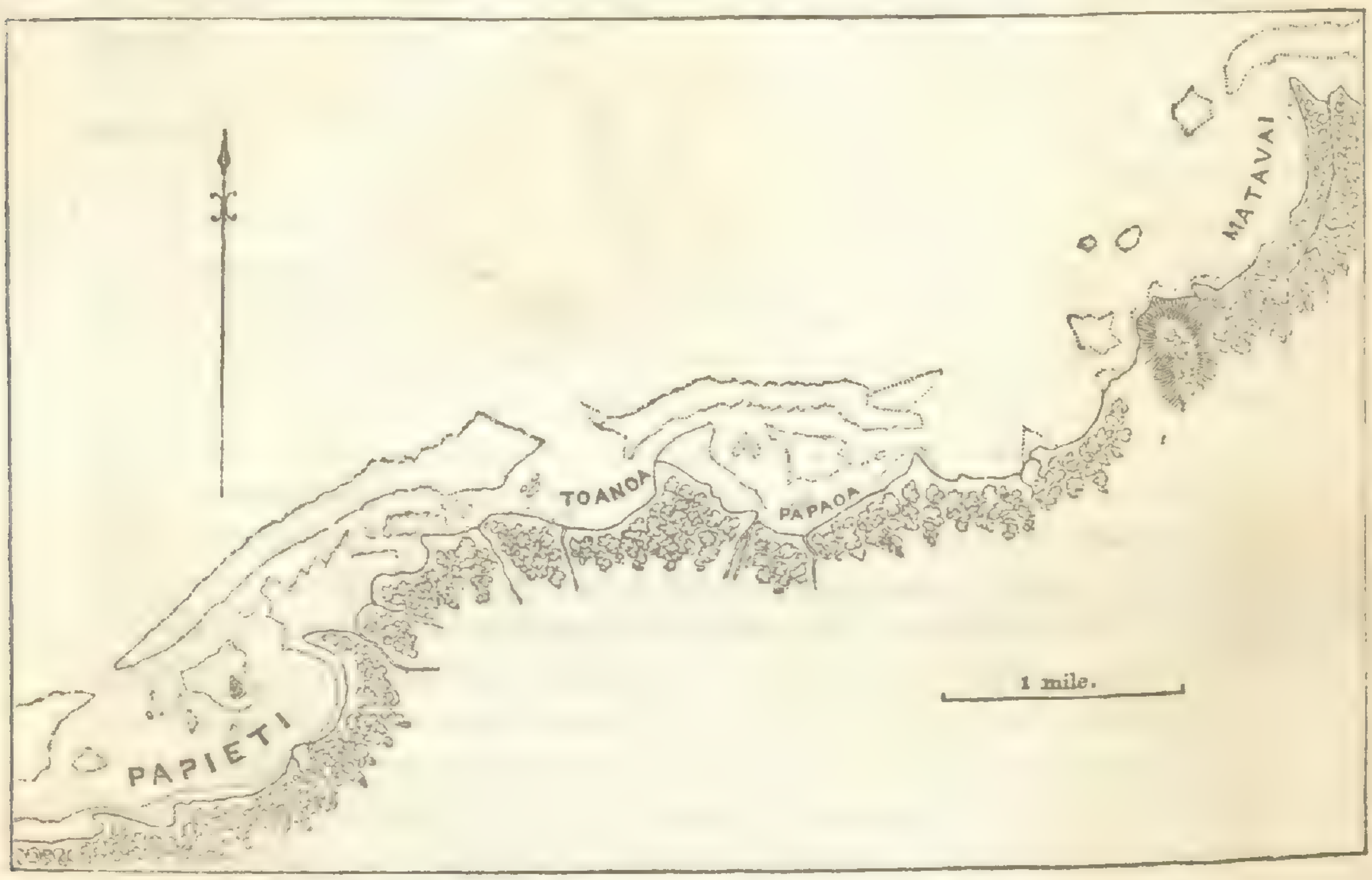
From these descriptions it appears that the main distinction between the inner and outer reefs consists in the less fragmentary character of the rock in the former case, the less frequent accumulations of debris on their upper surface, and the more varied features and slopes of the margin. Moreover, the Nullipores, which seem to flourish best in the breakers, are of less extent, or but sparingly met with elsewhere.

The inner margin of a barrier reef, it should be observed, is entitled to rank with inner reefs, as its corals grow in the same quiet waters, and under like circumstances. The variety of coral zoophytes is also greater in the stiller waters, and there are species peculiar to the different regions, as explained in another place.

Channels among reefs.—To complete this review of the general appearance and constitution of reef formations, it remains to add some particulars respecting the channels which intervene between coral patches, or separate them from the shores of an island, and also to describe the coral accumulations forming beaches.

The reef of New Holland has been instanced as affording an example of one of the larger reef-channels, varying from thirty to sixty miles in width, and as many fathoms in depth. The reefs west of the large Feejee Islands offer another remarkable example, the reef-grounds being in some parts twenty-five miles wide, and the waters within the barrier, where sounded, twelve to forty fathoms in depth. The barrier in this instance may be from a few hundred yards to a half a mile in width; and some of the inner patches are of the same extent; but by far the larger part of the reef-ground is covered with deep waters, mostly blue like the ocean, and as clear and pure. The sloop of war Peacock sailed along the west coast of both Viti Lebu and Vanua Lebu, within the inner reefs, a distance exceeding two hundred miles. The island of Tahiti on its northern side presents us with a good illustration of a narrow channel, and at the same time exhibits the usual broken or interrupted character of reefs. This is seen in the following cut in which the reefs, both fringing and barrier, are the parts enclosed by dotted lines. The outer reef

extends half to two-thirds of a mile from the shore. Within it, between Papieti and Matavai, there is an irregular ship channel, varying from three to twenty fathoms in depth. Occasionally it enlarges into harbors; and in other parts it is very intricate, though throughout navigable by large vessels. The island of Upolu, of the Samoan Group, is bordered by a reef nearly a mile wide on part of its northern shore; but the waters within are too shallow for a canoe at low tide; and therefore, notwithstanding its extent, the reef is rather a fringing than a barrier reef.



PART OF THE NORTH SHORE OF TAHITI.

The bottom of the channels or lagoons takes its character, as regards the material constituting it, either from the reefs, a source of calcareous sand and fragments, or from the earthy detritus of the island streams. At Upolu, the white coral sand of the reefs, (or in more general terms the reef debris,) forms the bottom; in some places it had the consistence of mud, and it was seldom observed to be covered with coarse material. There were some small patches of coral over it, and here and there a growing mass of Porites. The fresh waters of the shores do not flow over these wide reefs as there is no proper inner channel, and there is consequently no shore detritus mingled with the reef debris. At Tahiti, the sounding lead usually brought up sand, shells, and fragments of coral. At Tongatabu, the bottom, where the Peacock anchored, was a grayish blue mud, appearing as plastic as common clay; it consisted solely of comminuted coral and shells, with coloring matter probably from vegetable decomposition.

To the west of the larger Feejee islands, soundings commonly indicated a bottom of basaltic mud, and this material was frequently brought up with our dredges. On the north side of Vanua Lebu, a stream has so filled with its detritus the wide channel into which it empties, that for a mile our ship dragged its keel in the mud, although elsewhere the water had been from twelve to twenty fathoms deep; and at least half a dozen square miles of land had been added to the shores from this source. Though due principally to shore material, the reefs have probably added somewhat to these accumulations; yet little coral sand can be detected in the mud by the eye, and the proportion is certainly very small. In many places where we anchored, having the reef not more than five hundred yards from the ship, we might have judged, from the character of the bottom, that there were no corals nor shells within many miles. When the materials from both sources, the shore and the reef, are mingled, the proportion will necessarily depend on the proximity to the mouths of streams, the breadth of the inner waters or channels, and the direction and force of the currents. These tidal currents often have great strength, and are much modified and increased in force at certain places, or diminished in others, by the position of the reef with reference to the land. Sweeping on, they carry off the coral debris from some regions to others distant; and again they bear along only the shore detritus, and distribute it. It is thus seen that the same region may differ widely in its adjacent parts, and seemingly afford evidence in one place that there is no coral near, and in another no basaltic land, although either is within a few rods, or even close along side. The extent of the land in proportion to the reef will have an obvious effect upon the character of the channel or lagoon depositions. When the island stands like Bacon's isles, (Feejees,) as a mere point of rock in a wide sea enclosed by a distant barrier, the streams of the land are small and their detritus quite limited in amount. In such a case, the reef and the growing patches scattered over the lagoon, are the sources of nearly all the material that is accumulated upon the bottom.

Shore accumulations.—The wide coral banks and the enclosed channels greatly enlarge the limits tributary to the islands they encircle. They afford extensive fishing grounds for the natives and internal waters which enable them to practice and improve their skill in navigation, and communicate without danger between distant settlements; and the effect is evident in the spirit of maritime enterprise which characterizes the islanders: for these circumstances have favored the construction of large sail-canoes, in which they venture beyond their own land, and often undertake voyages hundreds of miles in length. Instead of a rock-bound coast, harborless and thinly habitable, like most extra-tropical islands, the shores are blooming to the very edge, and

wide plains are spread out with breadfruit and other tropical productions. Ports, safe for scores of vessels, are also opened by the same means, and some islands number a dozen, when the unprotected shores would have hardly offered a single good anchorage. Coral reefs are sometimes viewed as only traps to surprise and wreck the unwary mariner. But one who has visited the dreary prison-house, St. Helena, can have some appreciation of the benefits derived from the growth of the zoophyte.

The area of level shores, alluded to as added to many of the high islands by this means, is one of the most striking of these benefits. These plains are sometimes of large extent. The reefs stop the detritus from the hills, and are thus the means of its being added again to the land: they prevent, therefore, the waste which is constantly going on about islands without such barriers; for the ocean not only encroaches upon the unguarded shores of the smaller islands, but carries off whatever the streams may empty into it. The delta of Rewa, on Viti Lebu, resulting from the detritus accumulations of a large river, covers nearly sixty square miles. This is an extreme case in the Pacific, as few islands are so large, and consequently rivers of such magnitude are not common. But there is rarely an island which has not at least some narrow plains from this source; and upon them the villages of the natives are usually situated. Around Tahiti these plains are from half a mile to two or three miles in width, and the cocoanut and breadfruit groves are mostly confined to them.

Beach sandrock.—Besides the accumulations from a shore source, there are also beach formations derived from the reefs. The tides and the attending currents carry to the shores more or less coral sand with shells and other reef-relics, and these sometimes form large deposits. The material is mostly like common sand in fineness, but often somewhat coarser, or even like a bank of pebbles. When the barrier is distant, only the sand and smaller pebbles are met with; but if the reef is quite narrow, there may be larger fragments and masses of coral rock.

These deposits become cemented by being alternately moistened and dried, through the action of the recurring tides, and the wash of the sea on the shores. The waters take up some carbonate of lime which is deposited and hardens among the particles on the evaporation of the moisture at the retreat of the tides. In some places the grains are loosely coherent, and seem to be united only by the few points in contact; and with a little care, the calcareous coating which caused the union may be distinctly traced out. In other cases, the sand has been changed to an oolite, or to a solid rock, the interstices having been filled till a compact mass was formed. Generally, even the most solid varieties show evidence of a sand origin, and in this they differ from the reef-rock. The pebbly beds produce a pudding-stone of coral.

In all instances observed, these calcareous sand-rocks or conglomerates form a number of parallel layers along the coast, which dip regularly at an angle of five to eight degrees towards the water. The layers are from a few inches to a foot in thickness. They appear as if they had been tilted by some force from below, and are seen to outcrop successively, on receding from the water. Tutuila and Upolu in the Navigator Group, and Oahu in the Hawaiian, afforded us many examples of these beach formations. They seldom rise more than a few inches above high tide. At certain localities they appear to have been washed away after they were formed; and occasionally large masses or slabs have been uplifted by the sea, and thrown back on the beach.

Deposits of the same kind sometimes included detritus from the hills. Black basaltic pebbles are thus cemented by the white calcareous material, producing a rock of very singular appearance. Near Diamond Hill on Oahu, is a good locality for observing the steps in its formation. Many of the pebbles of the beach are covered with a thin incrustation of carbonate of lime, appearing as if they had been dipped in milk, and others are actually cemented, yet so weakly that the fingers easily break them apart.

The lime in solution in waters washing over these coral shores, is also at times deposited in the cavities or seams of the basaltic rocks; the cavities of the lava or basalt become filled with white calcareous kernels, and the cellular lava is changed into an amygdaloid. In large cavities or caverns, it often forms stalactites or stalagmitic incrustations.*

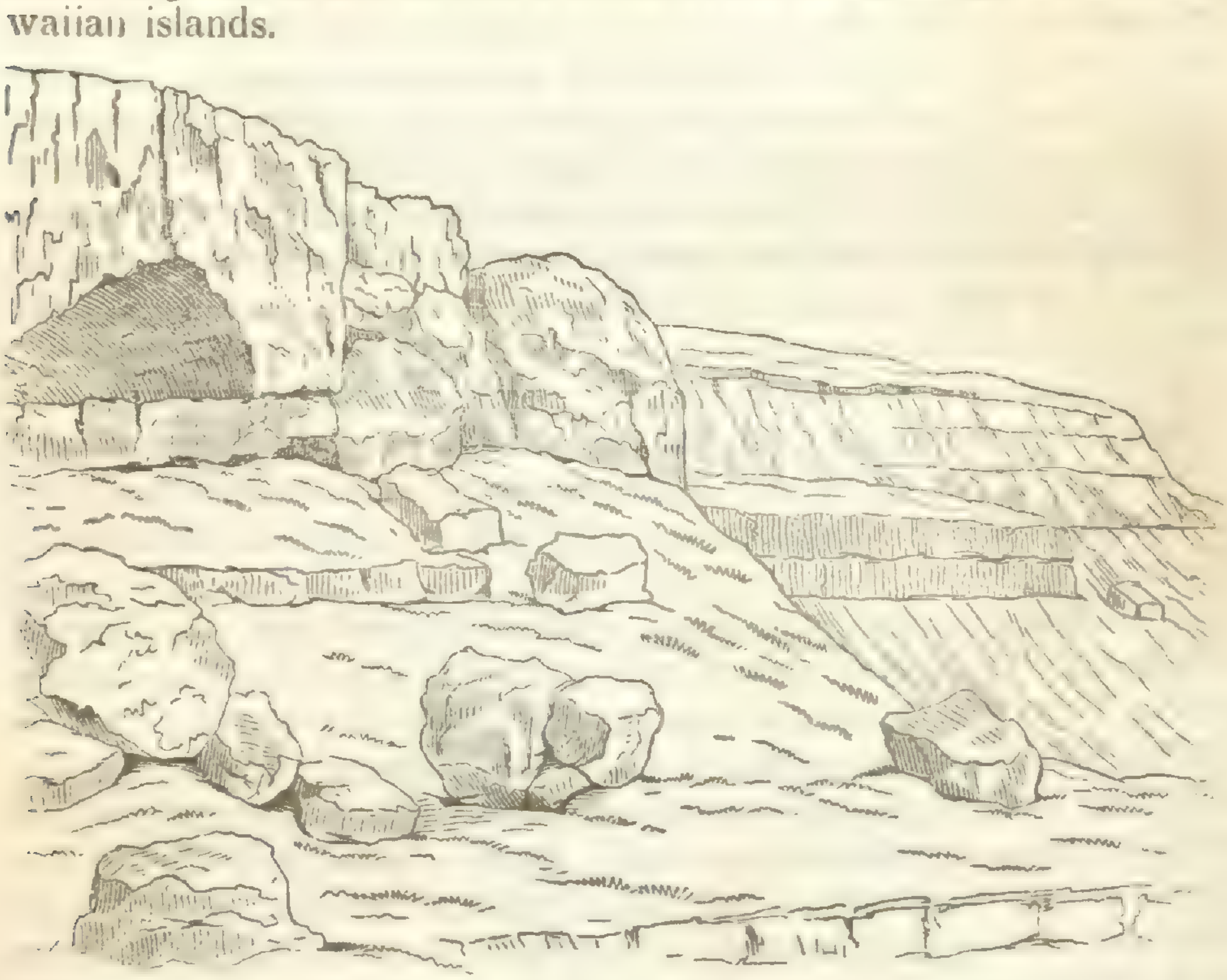
Drift sand-rock.—Still another kind of beach formation is going on in some regions through the agency of the winds in connection with the sea. It occurs only on the windward side of islands when the reefs are narrow, and proceeds from the drift sands.

The drifts resemble ordinary sand-drifts, and are often quite extensive. On Oahu, they occur at intervals around the eastern shores, from the *northern* cape, to Diamond Point which forms the *south* cape of the island,—the part exposed to the trades; and they are in some places twenty to forty feet in height. They are most remarkable on the north cape, a prominent point exposed to the winds that blow occasionally from the westward, as well as to the regular trades. They also occur on Kauai, another of the Hawaiian Islands. But at Upolu, (Samoa,) where the protecting reefs are broad, I met with no instance worthy of mention.

These sand-banks, through the agency of infiltrating waters, fresh or salt, become cemented into a sand-rock, more or less fri-

* Similar facts are stated by Mr. Darwin as observed on the shores of Ascension, and many interesting particulars are given respecting calcareous incrustations on coasts.—See Volc. Islands, p. 49. They were observed by the writer upon Madeira, in St. Jago, one of the Cape Verds, as well as among the basaltic islands of the Pacific.

able. The rock consists of thin layers or laminæ, which are very distinct, and indicate, generally, every successive drift of sand which puffs of wind had added in the course of its formation: and where a heavier gale had blown off the top of a drift, and new accumulations again completed it, the whole history is distinctly displayed in the rock. Several catastrophes of this kind may be made out from the character of the lamination in the sand-bluffs on the north side of Oahu. Since their formation, this island has undergone an elevation of twenty-five or thirty feet; these hills, once on the shores, are now seventy feet above the level of the sea, and they face the water with a bluff front (due to degradation), in which the lamination is finely exposed to view. The structure is best seen in a transverse section, presented on the west side. The layers are but a fraction of an inch thick: at one of the hills large slate-like slabs may be obtained; they have a sanded surface, but are so hard within as to clink under the hammer. A particular description of these bluffs is given in the author's remarks on the geology of the Hawaiian islands.



BLUFFS OF CORAL SAND-ROCK, NORTH SHORE OF OAHU.

One of the most interesting facts, observed in connection with these drift hills, is the absence of shells, and even of fragments of shells or corals, sufficiently large to be referred to either of these sources. The material is a fine sand, without organic remains, although situated on shores off which, within a hundred yards, there are shells and corals innumerable.

c. Thickness of reefs.

We have considered in the preceding pages the peculiarities of form and structure characterizing the reef formations bordering islands and continents, and their influence upon the enclosed land. Could we raise one of these coral-bound islands from the waves, we should find that the reefs stand upon the submarine slopes, like massy structures of artificial masonry; some forming a broad flat platform or shelf ranging around the land, and others encircling it like vast ramparts, perhaps a hundred miles or more in circuit. The reefs that were near the water-line of the coast would be seen to have stood in the shallowest water, while the outer ramparts rested on the more deeply submerged slopes. Indeed, it is obvious that with a given slope to the declivity of the land, the thickness of the reef resting upon it may be directly determined, as it would be twice as great two hundred feet from the shore as at one hundred feet. The only difficulty, therefore, in correctly determining the depth or thickness of any given reef, arises from the uncertainty with regard to the submarine slope of the land. It is, however, admitted as the result of extensive observation, that in general these slopes correspond nearly with those of the land above water. Mr. Darwin has thus estimated the thickness of the reefs of the Gambier Group and some other Pacific islands, and he arrives at the conclusion, as his figures indicate, that some coral reefs, at their outer limits, are at least *two thousand feet* in thickness.

It will be shown in another part of this volume, that the mountain slopes of the islands of the Pacific, except when increased by degrading agents, cannot be assumed to exceed twelve or fourteen degrees, and they are often but half this amount. The slopes of Mauna Kea and Mauna Loa, island of Hawaii, do not average over eight degrees. On the north side of Upolu, where the reefs are wide, the inclination is from three to six degrees. Throughout the Pacific, the *steeper* slopes of the mountains are due to agencies which cannot be shown to have affected the submarine slopes, excepting in cases of disruption of islands by forces below.

Assuming *eight* degrees as the mean inclination, we should have for the depth of reef, (or water,) one mile from the shore, 740 feet; or assuming *five* degrees, 460 feet. Adopting the first estimate, the Gambier Group would give for the outer reef a thickness of at least 1750 feet; or with the second, 1150 feet. The island of Tahiti, (taking the north side for data,) would give in the same manner 250 feet by the last estimate, which we judge to be most correct; Upolu, by the same estimate, 440 feet. The deduction for Upolu may be too large: taking three degrees as the inclination, it gives 260 for the thickness at the outer margin. The results are sufficiently accurate to satisfy us of the great thickness of many barrier reefs.

These calculations, however, are liable to error from many sources. Very different results might generally be obtained from different sides of the same island; and the same group often contains islands without reefs, and others with reefs one or even several miles from the shores. But since we may show that the absence of a reef or its limited extent may be traced to some causes restricting or modifying its formation, it is obvious that the error would probably be on the side of too low an estimate. Adjacent to the larger islands, such as those of Vanua Levu and New Holland, the error might be of the opposite kind; for the slopes of the land are of a more complex or irregular character than on the smaller islands. In the latter, they may be shown to belong generally to a single elevation of igneous origin, or at the most to two or three combined; while in the former, they may pertain to different ranges of hills or mountains. For correct results in any instance, the land and its declivities should be carefully studied beforehand, and the system in its inclinations determined by observation. With regard to Tahiti and Upolu, information bearing upon this point was obtained, and the above conclusions may be received with much confidence. Many of the Feejee reefs, on the same principle, cannot be less than 2000 feet in thickness.

Such accumulations of calcareous rock may appear to be an incredible work for the coral polyp, but only so, because we are not accustomed to contemplate the results which may proceed from the smallest agencies long continued. The operatives in the inorganic world are invisible molecules; and among living organisms, it is the lowest grade, the minims of existence, that have accomplished the grandest results in the earth's history.

ART. XLII.—*On the Infusoria and other Microscopic forms in Dust-showers and Blood-rain;* by Dr. C. G. EHRENBERG.*

THE infusorial character of the dust occasionally transported by winds, is one of the most wonderful of Ehrenberg's discoveries. His investigations have been reported from time to time, since May, 1844, and notices of some of his results have appeared in this Journal. A recent publication, whose title is given below, contains the details of his various researches, with full illustrations. The plates contain not only figures of all the forms observed in each case, but a sketch of a portion of the dust as it

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* *Passat-Staub und Blut-Regen*, ein grosses organisches unsichtbares Wirken und Leben in der Atmosphäre; Mehrere Vorträge von Dr. CHRISTIAN GOTTFRIED EHRENBERG, Ord. Prof. d. Medicin und Mitglied und beständ. Secretar der Akad. d. Wiss. zu Berlin, &c. Vorgetragen in der Königl. Preuss. Akad. der Wiss. zu Berlin, vom 23. Mai 1844 bis 1849. Abhandlungen der Akad., 1847. 192 pp. 4to with 6 colored plates, in folio. Berlin, 1849.

lay under the field of his microscope, exhibiting to the eye the relative prevalence of different forms and the colors they presented. The showers, whose microscopic organisms are here reported, are as follows:

I. *In the Atlantic, latitude* 17° 43′ *N., and longitude* 26° *W., about* 500 *miles from the coast of Africa.*—The dust was collected by Mr. Darwin, from the ship in which he was at the time. The direction of the wind was from the African coast. The dust resembled volcanic ashes, although evidently not of this origin, and about a sixth part of it was siliceous shells of fresh water and land infusoria and siliceous phytolites, eighteen species of the former, and as many of the latter. The most of the forms are European, and none exclusively African. Among them there is the South American species *Himantidium papilio*, which occurs at Cayenne, and also a *Surirella*, probably from the same continent. The conclusion follows, as Ehrenberg observes, that either the dust came in part from South America in the upper regions of the atmosphere, or these two species are yet to be discovered elsewhere. A list of the species in this and other showers is given in a following table.

II. *Other dust-showers in the Atlantic, from the collections of Mr. Darwin.*—These collections were made between the years 1834 and 1838, in latitudes 15°, 17°, 19° and 21°, part at San Jago, (Cape Verds) and part within 250 miles of the land in the open sea, between longitudes 22° and 26°. They afford thirty new forms to those of the shower above noticed, and include also the same South American forms, *Himantidium papilio* and *Surirella peruviana*. In addition, there are three species of Eunotia which have been found only in Senegambia and Guiana, together with the *Amphidiscus obtusus*, also South American. Besides the others, there was one Polythalamium, making in all 67 organic forms. The only new species was the *Eunotia longicornis* which is very similar to a Hungarian fossil species. No species peculiarly African was found in the dust; one, the *Lithostylidium Rajula*, occurs at the Isle of France.

III. *Dust which fell at Malta, 15th of May*, 1830.—This dust was obtained by Mr. Darwin from Purser R. G. Didham, of the ship Revenge. The wind at the time was east-southeast, and a similar fall of dust took place at the time, in the bay of Palmas in Sardinia. The number of species afforded was 43, of which 15 were Infusorial, 21 Phytolitharia, and 7 Polythalamia. Some of the species occur in Africa, yet there are no characteristic African forms. And although such showers with the hot winds that attend them, are usually referred to the Sahara desert, they appear to be quite foreign to that region. Among the species, *Synedra entomon* is a characteristic form from Chili. In general character, the species are like those of the Cape Verd and other Atlantic showers.

IV. *Sirocco dust, of Genoa, May* 16. 1846.—In this dust, Ehrenberg found 22 species of Polygastrica, 21 of Phytolitharia, and 3 of parts of plants. The forms have much resemblance to those of the Malta and Atlantic showers. The color is yellowish or ochreous, from oxyd of iron, and not gray like the true African dust, and about $\frac{1}{6}$th to $\frac{1}{3}$d of the mass is organic. None of the species are characteristic African forms, and *Synedra entomon* is South American. This dust was analyzed by Dr. Wolcott Gibbs, who obtained for its composition, excluding the water and organic matter which amounted to 18·53 p. c.,

S̈i	Ä̇l	F̈e	Ṁn	ĊaC̈	Ṁg	K̇	Ṅa	Ċu
45·575	20·547	9·388	4·222	11·648	2·209	3·645	2·332	0·306=100.

The carbonate of lime is from Polythalamia.

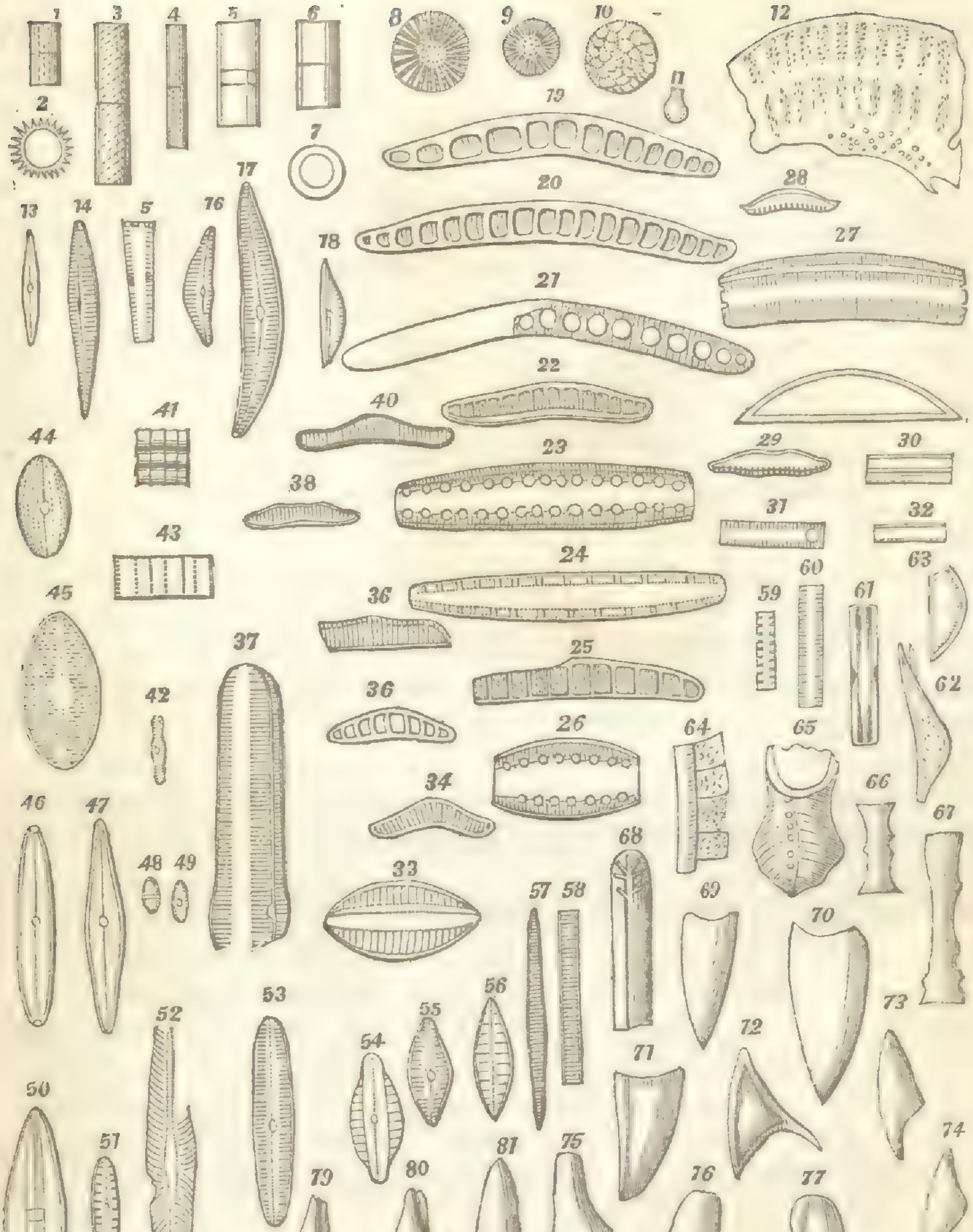
It follows from the preceding results that the showers of the Atlantic, of Malta and of Genoa are in general alike in organic as well as inorganic constitution, *and in the absence of characteristic African forms;* and this resemblance is the more surprising as the observations extend through the long period of 16 years, from 1830, to 1846. They are alike also in the brownish-red color of the dust.

V. *Sirocco dust of Lyons, Oct.* 17, 1846.—The Lyons shower afforded 39 species of Polygastrica, 25 of Phytolitharia, 3 of Polythalamia besides minute portions of plants. The accompanying plate from Plate 5, of Ehrenberg's work, contains 104 out of 123 of his figures, the species of Polythalamia, Spongolithis, and portions of plants being omitted. The species here figured are as follows:*

1. *Polygastrica.*

1, 2, Gallionella granulata.
3 —— decussata.
4 —— procera.
5, 6, 7 —— distans.
8, 9, Discoplea atmospherica.
10, Coscinodiscus?
11, Trachelomonas lævis.
12, Campylodiscus clypeus.
13, 14, 15, Gomphonema gracile.
16, 17, Cocconema cornutum (nec gracile.)
18 —— Lunula.
19, 20, Eunotia longicornis.
21, 22 —— longicornis.
23 —— Argus.
24 —— longicornis.
25 —— granulata?
26 —— zebrina? (Argus?)
27 —— Monodon?
28–32 —— amphioxys (31, *cum ovario*).
33, 34 —— gibberula.
35 —— zebrina?
36 Himantidium zygodon?
37 Eunotia gibba.
38 Eunotia tridentula.
39 Eunotia? lævis.
40 Himantidium Arcus.
41, 42, Tabellaria.
43 Fragilaria pinnata?
44 Cocconeis lineata.
45 —— atmospherica.
46 Navicula Bacillum.
47 —— amphioxys.
48, 49 —— Semen.
50 —— lineolata?
51 Pinnularia borealis.
52 —— viridula.
53 —— viridis.
54 —— tæniata (n. sp.)
55 —— æqualis?
56 Surirella Craticula?
57, 58, Synedra ulna.
59, 60, Fragilaria pinnata?
61 Grammatophora? parallela?
62, 63, Incerti generis (1).
64 Incerti generis (2).
65 Incerti generis (3) (Arcella costata?)

* In copying this plate, the oblique rows of dots on figure 3 are not made quite near enough together, and in fig. 8 the rays are too few in number.



MICROSCOPIC ORGANISMS OF THE LYONS DUST-SHOWER.

2. *Phytolitharia.*

66, 67, Amphidiscus truncatus.
68 —— obtusus.
69–71 Lithodontium furcatum.
72 —— Scorpius.
73, 74 —— rostratum.
75–77 —— Bursa.
78 —— angulosum.
79 —— nasutum.
80 —— triangulatum.
81 Lithostylidium clavatum.
82 *a*, —— Serra.
82 *b*, —— Taurus.
83–85 —— curvatum.
86 —— biconcavum.
87 —— Clepsammideum.
88 Lithosphæridium irregulare.
89 Lithostylidium Clepsammideum.
90 —— crenatum.
91 —— Ossiculum.
92 —— Amphiodon.
93 —— Terebra.
94 —— angulatum.
95 —— rude.
96, 97 —— denticulatum.
98 —— Emblema.
99 —— irregulare.
100 Lithomesites ornatus.
101 Lithostylidium triceros.
102 —— calcaratum.
103 —— spiriferum.
104 —— læve.

In this shower, the organic forms make up about *one-eighth* of the mass. In general character including color, there is a close resemblance to the products of the Atlantic showers and the others above described. The species are nearly all of fresh-water or land origin; one-seventh only are marine species. The most abundant forms of Polygastrica, are *Eunotia amphioxys*, *E. gibberula*, *E. longicornis*, *Gallionella decussata*, *G. granulata*, and *G. procera*; and those of Phytolitharia, *Lithostylidium amphiodon*, *L. ossiculum* and *L. rude*.

There are two South American species, the *Eunotia Pileus* and *Himantidium Zygodon*.

The number of species brought to light from the dust of the nine showers thus far described, is as follows:

Polygastrica 57. Phytolitharia 46. Polythalamia 8.

Besides these, there are seven kinds of particles from plants, and one fragment of an insect. Seventeen of the species are marine, and the other 102 of fresh-water origin. There is no evidence of volcanic origin.

VI. *Second specimen from the Genoa shower of the* 16*th of May*, 1846.—All but one of the forms mentioned were observed in the former specimen of the dust.

VII. *Storm of red snow in Puster Valley in Tyrol, March* 31, 1847.—This red snow owed its color to a colored dust, much resembling that of the Atlantic. Its tint is brownish red.

It afforded, as obtained at two localities, 66 organic forms, 22 of which were Polygastrica, 28 Phytolitharia, 2 Polythalamia, 13 particles of plants, and 1 of an insect. The large majority of the species are known fresh-water and continental forms: only 4 to 6 species are unknown; 2 are marine, namely, *Coscinodiscus radiolatus* and a *Spiroloculina* (?) There is a remarkable resemblance in the color and character of the dust to that of the Atlantic, Genoa and Lyons, and an identity in many of the species. Forty-six species out of the 66 occur in the Sirocco and Atlantic dust. Twelve

Polygastric species and 20 Phytolitharia are common to the Atlantic showers and the Tyrolese snows. This uniformity of character over regions so widely separate, yet in nearly a common latitude or zone, and in so many distinct examples through a number of years, is most surprising.

VIII. *Dust which fell in Italy in* 1803, *and in Calabria in* 1813.—The former of these showers is represented as coming from the southeast. It afforded 49 species, and that of Calabria 64. Out of the 49, 39 have been observed in the more recent showers; and out of the 64, 51 are like the more recent. These showers, although 10 years apart, have 28 species in common, or about one-fourth. In both nearly all the species are of fresh-water or continental origin. In both, as in other showers, the most abundant species are *Eunotia amphioxys*, *Gallionella granulata*, *G. crenata*, *G. distans*, *G. procera*, *Lithodontia*, *Lithostylidia*. In both, also, there are four South American forms; *Coscinodiscus flavicans* from Peru and St. Domingo, *Navicula undosa* from Surinam, *Stauroneis linearis* from Chili and North America, *Synedra Entomon* from Chili. The last occurs also in Africa and Asia. There are no characteristic African species.

Ehrenberg next mentions facts of a similar kind of earlier date. Humboldt when in Paramo, on the way from Bogota to Popayan, at a height of 2300 toises (14,700 feet), observed a red hail, a fact published by him in the Annales de Chimie for 1825. The height of the place gives peculiar interest to the observation.

In 1755, on the 14th of October, at 8 o'clock in the morning, a warm Sirocco wind was blowing at Locarno near Lago Maggiore. At 10 o'clock the air was filled with a red mist, and at 4 o'clock P. M. there was a blood-red rain, which left a reddish deposit, equal to one-ninth of its mass. There fell nine inches of this rain in one night. About 40 square German leagues were covered with this bloody rain, which also extended on the north side of the Alps into Suabia, and nine feet of reddish snow fell upon the Alps. Supposing that the deposit averaged but two lines in depth, there would be for each square English mile, an amount equal to 2700 cubic feet. But actual measurement gave for the depth in some places about one inch (or $\frac{1}{9}$th of 9 inches).

In 1623 there was another blood-rain at Strasburg. It happened on the 12th of August, between the hours of 4 and 5 in the afternoon. In the year 1222 a similar rain fell at Rome for one day and night. Many other like facts are cited.

Ehrenberg favors the view of the atmospheric origin of these showers, and speaks of their relation to the fall of aerolites. Chladni in his work on meteorites observes that the stones which fell between 1790 and 1819, amounted to not less than 600 hundred weight: while for the single dust-shower of Lyons in 1846, the material that fell was full 7200 hundred weight.

The Cape Verd shower had a breadth, according to Darwin,* of more than 1600 miles, and according to Tuckey, of 1800 miles, and extended 6 to 800 miles or even 1000 miles from the African coast. This gives an area of 960,000 to 1,280,000, or from 1,648,000 to 1,854,000 square miles.

The surface of Italy is about 90,000 square miles; that of Sicily 10,000 square miles, making together 100,000. A single dust-shower, covering both countries like that of 1803, to the extent of that of Lyons in 1846, would deposit 112,800 hundred weight of dust in a single day. With such facts before us, Ehrenberg asks, how many thousand millions of hundred weight of microscopic organisms have reached the earth since the period of Homer, the time of our earliest record of such events? He adds, I cannot longer doubt, that there are relations, according to which, living organisms may develop themselves in the atmosphere:— and he speaks of this as a self-development and not a production from introduced ova.† He supposes it probable that the atmospheric dust-cloud region is of vast extent, and is above a height of 14,000 feet. The facts may seem inexplicable on any other hypothesis; yet much more investigation will be required before an opinion so contrary to received principles, can be generally adopted.

The work proceeds with a historical relation of all showers of dust, blood-rain, red snow and similar phenomena, from the earliest records to the present time. This history occupies 100 pages of the volume.

The *first* instance adduced dates about 1500 years before the present era. It is the plague of blood inflicted upon the Egyptians, as related in the Mosaic history, which prevailed throughout the whole land of Egypt, continuing three days and three nights.

The *second* occurred about 1181 B. C., the time of Æneas and Dido, as related by Virgil, Æneid, iv, 454.

> Horrendum dictu, latices nigrescere sacros
> Visaque in obscœnum se vertere vina cruorem.

The *third* about 950 B. C., as described by Homer, Ilias xi, v. 52, 54, and also Ilias xvi, v. 459, 460.

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* Quart. Jour. Geol. Soc., No. 5, 1846, p. 26.

† Ehrenberg observes on page 57:— "Ich darf ferner jetzt kaum mehr zweifeln dafs es Verhältnisse des sich fortentwickelnden Lebens in der Atmosphäre giebt. Diese beiden neuesten Staubarten, welche so hochst massenhaft gefallen sind, tragen die Spur der Existenz und der Fortentwicklung (nicht durch Eibildung, aber durch Selbsttheilung) kieselschaliger Formen zu deutlich. Dennoch kann ich das Verhältnifs der Phytolitharien und Seethiere halber, welche sich darunter befinden, nicht ein kosmisches nennen. Ich kann mich auch deshalb mit demselben noch nicht ganz befreunden, weil Leben und Fortenwicklung nur bei gleichzeitiger Feuchtigkeit bestehen kann, welche zwar das Leben begünstigt und entwickelt, aber nicht gleichzeitig die rothe Farbe des Staubes und die feinen Pflanzentheile vor Veränderung, Verrotten, schützen kann, was durch Trockenheit sicher erreicht wird. Mischen sich daher zuweilen verschiedenartige Verhältnisse?"

The *fourth* about 910 B.C., is the instance of bloody waters mentioned in connection with the victory over the Moabites in 2nd Kings, iii, v, 21, 22, 23.

Ehrenberg mentions then the rain of blood in the time of Romulus, as related by Livy, and goes on with other accounts of subsequent date, with regard to which the information is not of as doubtful character as with those just alluded to.

A supplemental chapter contains a notice of meteoric dust showers since 1846. One on the 31st of March, 1847, in the valley of Gastein, in Salzburg; another in Arabia, Jan. 24, 1848; another in Silesia and Lower Austria, Jan. 31, 1848. The showers afforded similar fresh-water and continental forms, with the same South American species before mentioned, and no characteristic African form. Other showers occurred in 1849. In March there was a reddish dust fell at Catania in Sicily, during a south wind. On the 14th April, during a hail storm in Ireland, there was a black inky deposit, affording numerous microscopic organisms.

The number of showers which Ehrenberg records is in all 340, 81 before Christ and 249 after Christ. These occurred in different centuries as follows:

1. *Before the Christian Era.*

Century.	Showers.	Century.	Showers.	Century.	Showers.
16th	1	5th	4	2nd	28
10th	3	4th	4	1st	18
8th	1	3d	22		

2. *In the Christian Era.*

Century.	Showers.	Century.	Showers.	Century.	Showers.
1st	5	8th	6	15th	6
2nd	1	9th	10	16th	51
3d	2	10th	5	17th	31
4th	4	11th	6	18th	29
5th	2	12th	11	19th	63
6th	10	13th	6		
7th	3	14th	8		

These showers or falls of dust, blood-rain, red snow or the like, occurred in the different months, as far as known, as follows:

January,	27	May,	18	September,	7
February,	14	June,	18	October,	18
March,	23	July,	9	November,	16
April,	18	August,	17	December,	14

From October to March, the winter part of the year, the number is 112, from April to September, the summer part, 87. From January to June the number is 118, and from July to December, 81.

The following is a general view of the periods of recorded showers arranged according to the countries where they occurred.

1. Italy and adjoining Islands.

A. C. 718 710 461 344 295 294 262 223 217 216 215 214
213 212 211 210 209 208 205 203 202 200 194 193
192 191 190 188 184 183 182 181 177 172 169 167
166 163 152 147 143 140 137 136 134 128 126 125
124 118 117 114 111 108 106 102 100 99 98 96
95 94 93 92 91 88 75 53 48 44 42 41
37 30 10.

P, C. 14 54 61 68 70 79 90 202 570 594 746 859
864 1104 1113 1114 1128 1222 1456 1530 1652 1689 1729 1791
1803 1808 1809 1810 1813 1816.

In *Lombardy.*—P. C. 869 874 1510.
In *Sardinia.*—A. C. 217 — P. C. 220.
In *Sicily.*—A. C. 217 — P. C. 559 1803 1849.
In *Malta.*—P. C. 1830.
In *Genoa.*—P. C. 935 1678 1744 1814 1841 1847.

2. Germany (including Holland, Prussia, Austria, and Germanic states.)

P. C. 787 823 839 869 1006 1009 1010 1117 1120 1146 1226 1337
1348 1349 1376 1416 1434 1438 1501 1502 1503 1534 1539 1540
1543 1547 1548 1559 1550 1551 1552 1553 1554 1555 1556 1557
1568 1571 1572 1576 1586 1618 1620 1638 1645 1645 1646 1647
1668 1676 1677 1691 1716 1721 1745 1755 1763 1764 1803 1821
1847 1848 1849.

In *Hungary* 1546, 1848; In *Poland* 1269, 1550.

3. France.

P. C. 434 464 541 581 583 860 1011 1114 1163 1165 1551 1559
1560 1608 1616 1617 1623 1634 1658 1669 1676 1731 1748 1763
1765 1830 1839 1841 1841 1846.

4. Spain and Portugal.

A. C. 75.
P. C. 531 1438? 1531 1551.

5. Greece and European Turkey.

Greece.—A. C. 480 488.—P. C. 1147 1637 1194.
Turkey.—P. C. 266 458 473 512 652 782 860.

6. England, Sweden, Russia.

England.—P. C. 53 570 1274 1755 1849.
Sweden.—P. C. 1319 1529 1629 1711.
Russia.—P. C. 1755 1849?

7. Africa.

A. C. 1577 400 37 35 30 18
1. P. C. 1160 1181 1421 1555 1557 1606 1627 1810 1815 1817 1820 1821
1822 1825 1826 1836 1837 1838 1838 1839 1839 1839 1840 1840
2. *Open sea, in the Atlantic.*
P. C. 1579 (1631) 1668 1683 1692 1719 1812 1816 1830 1833 1834
3. *Cape Verds.*—P. C. 1579 1692 1833.
4. *Canaries.*—P. C. 1683?

8. Asia.

1. *Arabia.*—P. C. 570 1065 1365 1680 1825.
2. *Palestine.*—A. C. 910 332 100;—P. C. 610 1348 1546 1637.
3. *Asia Minor.*—A. C. 950.—P. C. 358 860 897 929 1819.
4. *Persia.*—P. C. 1076.
5. *India.*—P. C. 1680 1815? 1835 1846.
6 *China.*—P. C. 333 811 1334.
7. *Indian Ocean.*—P. C. 1665? 1665 1801? 1815?

9. America.

1. *S. America.*—P. C. 1635? 1680 1737 1799 1802 1812.
2. *N. America.*—P. C. 1741 1780 1785 1814 1843 1843.

10. Australia.

P. C. 1841?

The volume closes with a series of conclusions from the facts mentioned. Ehrenberg remarks that these showers appear to prevail most within a zone extending from the part of the Atlantic off the west coast of Middle and North Africa, along in the direction of the Mediterranean sea, reaching a short distance north of this sea, and continued into Asia between the Caspian sea and the Persian Gulf, perhaps to Turkistan, Kaschgar and China; and they seldom reach north to Sweden and Russia. This zone according to the observations of Tuckey, has a breadth of 1800 miles in the North Torrid zone. The reddish color of the dust as well as the organic forms, show that the dust is not of African origin. Moreover the storm-winds and sirocco are found to afford the same species of organisms.

Ehrenberg repeats again his opinion that these phenomena are not to be traced to mineral material from the earth's surface, nor to revolving masses of dust material in space, nor to atmospheric currents simply: but to some general law connected with the earth's atmosphere according to which there is a self-development within it of living organisms.

The whole number of species of organisms observed is 320. Of marine genera there are only the following: *Coscinodiscus*, *Diploneis*, *Goniothecium*, *Grammatophora*, and *Biddulphia*, besides some Polythalamia and Spongolites. The following are American forms:

Arcella constricta.	Eunotia quaternaria.	Navicula undosa.
Desmogonium Guayanense.	" quinaria.	Stauroneis dilatata.
Eunotia Camelus.	Gomphonema Vibrio.	Suririella Peruana.
" depressa.	Himantidium Papilio.	Synedra Entomon.
" Pinus.	" Zygodon.	Fragmenta incerta—3.

A simultaneous occurrence of dust-showers and falls of meteoric stones, has been observed in probably *eighteen* instances before the Christian era. During the Christian era, *fourteen* coincidences have been observed, making thirty-two in all.

We insert here from this most remarkable work of Ehrenberg the following tables, which present to the eye the range of showers through which the different species of organisms have been observed.*

* The numbers in the table, following the names of the species, refer to the figures of these species on the plate, page 375.

Some of the columns, where there were several for the same shower, have been omitted in copying this table. These omitted columns relate to the storms of 1847 and 1848,—III and IV, in the tables; and any species of these storms not belonging to the columns inserted, are marked by a † instead of an *.

I. Atlantic Dust-showers.—II. Sirocco Dust-showers (in 1813, with meteoric stones).—III. Dust-storm of Tyrol and Saltzburg, 1847.—IV. Winter Dust-hurricane in Silesia and Lower Austria, 1848.—V. Ink-rain, in Great Britain, 1849.

Table I.—Species of Polygastrica.

	I.						II.						III.	IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Saltzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Achnanthes?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Amphora libyca,	.	.	.	.	.	.	*	*?	*	.	.	.	*	.	.	*	
Arcella constricta,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Enchelys (hyalina),	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
? costata (65),	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
vulgaris,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Biddulphia?	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.		
Campylodiscus Clypeus (12),	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Chætoglena volvocina,	.	*?	.	.	.	.	.	.	.	.	*?						
Chætotyphla? reticulata,	.	.	.	.	*												
saxipara,	.	.	.	.	.	.	.	.	.	.	*						
Closterium ?	.	.	.	.	.	.	.	.	.	.	.	.	.	.		†	
Cocconeis atmospherica (45),	.	.	.	.	.	.	.	.	.	.	.	.	*				
finnica,	.	.	.	.	.	.	.	.	*?								
lineata (44),	.	.	.	.	.	.	.	.	.	.	*	.	*				
Cocconema cornutum (16, 17),	.	.	.	.	.	.	.	.	.	.	*	.	*				
Leptoceros,	*?	*	.	.	.	.	*										
Lunula (18),	*	*	.	.	.	.	.	.	.	.	.	*?	*				
Fusidium,	.	.	.	*	.	*	.	*									
lanceolatum,	.	.	.	.	.	.	.	*?									
Coscinodiscus flavicans,	*	.	*?	.	.	.	.	.	*?								
lineatus,	.	.	.	.	.	.	.	.	*?								
radiatus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*		
radiolatus,	.	.	.	.	.	.	*	.	.	.	.	.	.	*?			
? (minor),	.	.	.	.	.	.	.	.	*								
? (10),	.	.	.	.	.	.	.	.	.	.	.	.	*				
Desmogonium guyanense,	.	*?	.	.	.	.	*?	.	.	.	*?	.	.	.	.	†	
Difflugia areolata,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
cellulosa,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Diploneis didyma,	.	.	.	.	.	.	.	.	.	.	*						
Discoplea atmospherica (8, 9),	*	*	.	*	*	.	*	*	*	*	*	*	*	.	*		
atlantica,	*	*								*?	*?						
?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
sinensis ?	.	*	.	.	*	.	.	.	*	.	.	.	.	.	*		
Eunotia amphioxys (28–31),	*	*	.	*	*	*	*!	*!	*!	*	*!	*	*!	*	*	*!	*
Argus (23),	.	*	*	.	*	.	*	.	*	*	.	*	*	*			
Camelus,	.	.	.	.	*	.	.	.	*?								
depressa,	.	.	.	.	*												
Diodon,	.	.	.	.	.	.	.	.	*	.	*?						
gibba, (37),	*	.	*	*	.	.	*	*	*	*?	.	.	*	.	*		
gibberula (33, 34),	.	*	*	*	*	*	.	*	*	*?	.	.	*				
granulata (25),	.	.	.	.	*?	*?	.	.	*?	.	.	.	*?				
? lævis (39).	.	.	.	.	.	.	.	.	.	.	.	.	*				
longicornis (19–22),	*	.	*	.	*	*	*	.	*	.	.	.	*	*	*		
Monodon (27),	.	.	.	.	.	.	.	.	.	.	*?	.	*?				
Pileus,	*	.	.	.	.	.	.	.	.	.	.	.	*				
quaternaria,	.	*															

Table I.—*Continued.*

	I.						II.							III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38.		Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846.		Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					A	B					A	B					
Eunotia quinaria,	·	*															
Textricula,	·	·	·	·	·	·	·	·	*	*							
tridentula (38),	*?	·	·	·	·	·	·	*	·	·	*	·	*				
Triodon,	*	·	·	*	*	*	·	·	·	·	*						
Zebra,	·	·	*?	*?	*?	*?	·	·	·	·	·	·	·	·	*?		
zebrina (26? 35?),	·	*	*	*	*	*	*?	*?	*?	·	*	·	*?	*			
Fragilaria amphioxys,	·	·	·	·	·	·	*?										
? (Biblarium?)	·	·	·	·	·	·	·	·	·	·	·	·	·	*			
constricta,	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·		†
diophthalma,	*	·	·	·	*?	·	·	*?	*								
pinnata (43),	*?	·	·	·	*?	*	·	·	·	*	·	·	*?	*			†
rhabdosoma,	·	·	·	*	*	·	·	*?	*	*?	*?	·	·	·	·		
? Synedra,	·	·	·	·	·	·	*	·	*	·	*						
Gallionella crenata,	*	*	*	*	*	*	*	*	*	*	*	·	·	*	*		
decussata (3),	·	·	*	*	·	·	*	*	·	*	·	*	*				
distans, (5, 6, 7),	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
ferruginea,	*?	*?	·	*?	*?	*?	*?	*?	*?	·	*?	*?	*?	*?	*?		
granulata (1, 2),	*	*	*	*	*	*	*!	*	*	*	*	*	*	*	*		
laminaris,	·	·	·	·	·	·	*	*	*?	·	·	·	·	*	*		
marchica,	·	·	·	·	*	·	*										
procera (4),	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
tæniata,	·	·	·	*													
Gomphonema clavatum,	·	·	·	·	·	·	·	·	·	·	·	·	*?				
gracile, (13, 14, 15),	*	*	·	·	*?	·	·	*?	·	*?	·	·	*	·	*		†
longicolle,	·	·	·	·	·	·	·	·	·	·	·	·	*				
rotundatum,	·	·	·	·	*	*?	·	·	*								
truncatum,	·	·	·	·	·	·	·	·	·	·	·	·	·	*			
Vibrio,	·	·	·	·	·	*?											
Goniothecium crenatum,	·	·	·	·	·	·	·	·	·	·	*						
Grammatophora oceanica,	·	*?															
parallela (61?),	·	*?	·	·	·	·	·	·	·	·	·	·	*?				
Himantidium Arcus (40),	*	*	·	*	*	·	·	·	*	·	*	·	*				
gracile,	*	·	*														
Papilio,	·	*?	·	·	*												
Zygodon (36?),	·	·	·	·	·	·	·	·	·	·	·	·	*				
Meridion vernale,	·	·	·	·	·	·	·	*									
Monas viridis,	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*!
Navicula affinis,	*	*	·	·	*	·	·	·	·	·	*	·	*				
amphioxys (47),	·	·	·	·	·	·	·	·	·	·	·	·	*				
Bacillum (46),	·	*	·	·	*?	·	·	·	·	*	·	·	*?				
dubia,	·	·	·	·	·	·	·	*									
emarginata,	·	·	·	·	·	·	·	·	*								
fulva,	·	·	*	·	·	·	·	·	*								
gracilis,	·	·	·	·	·	*	·	·	·	·	*						
lineolata (50?),	*	·	·	*	*	·	·	·	*	·	·	·	*				
Scalprum,	·	·	·	·	·	·	*										
Semen (48, 49,),	·	·	·	·	*	·	*	·	*	·	*	·	*?	·	*	†	*
undosa,	·	·	·	·	·	·	·	·	*								
?	·	·	·	·	·	·	·	·	·	·	·	*					
?	·	·	·	·	·	·	·	·	·	·	·	·					
Pinnularia æqualis (55?)	*	*	·	*	*	*?	·	·	·	·	·	·	*	*			
affinis,	·	*	·	·	·	·	·	·	·	·	·	·	·	·	·	†	

Table I.—*Continued.*

	I.						II.						III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pinnularia amphioxys,	.	*															
borealis (51)	.	*	.	*	*	.	.	*?	*	.	*	.	*	*	*	*	
gibba,	.	.	.	.	*												
nobilis,	.	.	.	.	.	.	.	.	.	.	*						
tæniata (54),	.	.	.	.	.	.	.	.	.	.	.	.	*	*			
Termes,	.	.	.	.	.	.	.	.	.	.	*						
viridis (53),	*?	*	.	*	*	.	*?	.	*	.	.	.	*	.	*?	†	
viridula (52),	*	*	.	*	*	*?	.	.	.	.	.	.	*	*	†		
?	.	.	.	.	.	.	.	.	.	.	.	.	.	*			
? (Amphora ?).	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Podosphenia Pupula,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*		
Pyxidicula (Coscinodiscus ?),	.	.	.	.	.	.	*?										
Spirillum Undula,	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	*!
Stauroneis dilatata,	*																
Legumen,	.	.	.	.	.	.	.	.	*								
linearis,	.	.	.	.	.	.	.	.	*								
Phœnicenteron,	.	*	*														
Semen,	.	.	.	.	.	.	.	.	.	.	*?	.	.	*			
Stauroptera cardinalis,	.	.	.	.	.	.	*?	.	*								
parva,	.	*															
Staurosira construens,	.	.	.	.	.	.	.	.	*								
Surirella Craticula (56?),	.	.	.	.	.	.	.	.	*	.	*	.	*?	*			
? Entomon,	.	.	.	.	.	.	.	.	*								
? paradoxa,	.	.	.	.	.	.	.	.	*								
peruana,	.	.	.	.	*?												
undulata,	.	*?	.	.	.	.	.	*?									
Synedra capitata,	.	*															
Entomon,	.	*	.	*	.	*?	*!	*!	*!	*?	*	*	.	.	*	*	
Ulna, (57, 58),	*	*	*	.	*?	*	*	*	*	*	*	-	*	*	*	†	*
?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
?	.	*															
Tabellaria ? (41, 42),	.	.	.	.	.	.	.	.	.	.	*?						
?	.	.	.	.	.	.	.	.	.	.	.	.	*				
Trachelomonas lævis (11),	.	*	.	.	*?	.	.	.	.	.	.	.	*	.	†	†	
Fragmenta incertæ, 1	.	.	.	.	.	.	.	.	.	.	.	.	*				
Fragmenta incertæ, 2	.	.	.	.	.	.	.	.	.	.	.	.	*				
Fragmenta originis, 3	.	.	.	.	.	.	.	.	.	.	.	.	*				
	137	29	40	17	24	39	22	28	26	46	19	35	12	48	20	19	4§	5

§ The number of species from the specimen of dust of this storm collected at Hirschberg, was 8; and from Niesky, 10.

Table II.—Phytolitharia, Polythalamia, etc.

	I.						II.						III.			IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38.		Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846.		Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
					A	B					A	B					
PHYTOLITHARIA.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Amphidiscus armatus,	.	.	*?	.	*	.	.	.	.	.	.	*					
clavatus,	.	.	.	*	*	.	.	.	*	*	*						
fistulosus,	.	.	.	.	*												
Martii,	.	.	*	.	.	.	.	.	.	.	*						
obtusus (68),	*	*	.	*	*	*	.	.	.	*	*	.	*	*	†		
Rotella,	.	*	.	.	.	.	*										
Rotula,	.	.	*														
truncatus (66, 67),	*	*	*	*	*	.	*	*	*	*	*	.	*	*	*	*	
Assula (*silicea?*§) hexagon.																	
umbonata,	.	.	*	.	.	.	*	.	.	.	.	.	.	.			
Lithasceriscus tuberculatus,	.	.	.	.	.	.	.	*	.	*	*	.	.	.	*	*	
Lithochæta lævis,	.	.	.	*	.	.	.	.	.	.	.	.	.	†	.	†	
Lithodontium angulosum (78),	.	.	.	.	.	.	.	.	.	.	.	.	*				
Bursa (75–77),	.	.	*	*	*	*	*	.	*	*	*	.	*	*	†	†	*
curvatum,	.	.	*	.	*	*	*	.	*	*	.	.	*	.	†	†	
excisum,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
falcatum,	.	.	.	.	.	.	*?	.	.	.	.	.	.	*			
furcatum (69–71),	.	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*
nasutum (79),	.	.	*	*	*	*	.	.	*	*	*	.	*	*	*	*	
obtusum,	.	.	.	.	.	.	*?	.	.	.	.	.	.	.	.	*	
platyodon,	.	.	.	*	*	.	.	.	*	.	.	*	*	†	.	*	
rostratum (73, 74),	*	*	*	*	*	*	*	.	*	*	*	*	*	*	†	*	*
Scorpius (72),	.	.	.	.	.	.	*	.	.	.	*	.	*	.	.	*	
triangulum (80),	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	
truncatum,	.	.	.	.	*												
Lithomesites ornatus (100),	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	†	
Pecten,	.	.	.	.	.	.	.	.	.	.	*	.	*				
Lithostomatium ellipticum,	*																
Rhombus,	.	.	.	.	.	.	.	.	*	.	*						
Lithosphæridium irregulare,	.	*	.	.	.	.	*	.	.	.	*	.	*	†			
Lithostylidium Amphiacanthus,	.	.	.	.	*	*											
Amphiodon (92),	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
angulatum (94),	.	*	.	.	*	.	*	.	.	*	.	.	*	.	*	*	
articulatum,	.	.	.	.	.	*	.	.	.	.	.	.	*	†			
biconcavum (86),	.	*?	*	*	*	*	*	.	*	*	*	*	*	*	*	*	
calcaratum (102),	.	.	*	.	*	.	*	.	.	*	.	.	*	.	*	*	
Cassis,	.	.	.	.	.	.	.	.	*								
Catena,	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
clavatum (81)	.	*	*	*	*	.	*	.	*	*	*	.	*	†	†	†	
Clepsammidium (87)	*	*	*	*	*	*	*	.	.	*	*	*	*	*	.	*	*
comptum,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
crenulatum (90),	.	*	.	*	.	.	.	*	.	*	*	.	*	†	*	†	
curvatum (83–85),	.	.	*	.	.	.	.	.	.	*	*	.	*	.	†		
denticulatum, (96,97)	.	*	.	.	*	.	*	.	*	*	*	.	*	*	*	†	
Emblema, (98?)	.	.	*	.	.	.	.	.	.	*	.	.	*	†	.		
falcatum,	.	.	.	*	.	.	.	.	.	.	*	.	.	.	*		
Fibula,	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	*	
Formica,	.	*	.	.	.	.	*	.	*	*	*	.	.	.	.	†	

§ Not dissolved in acids.

Table II.—*Continued.*

	I.						II.						III.		IV.	V.
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Lithostylidium irregulare (99),	.	.	*	*	.	*	.	.	*	.	.	.	*	*			
læve (104),	.	.	.	*	*	*	.	*	*?	*	*	.	*	*	.	†	*
Lima,	.	.	.	.	.	.	.	.	.	.	.	.	.	*			
obliquum,	.	*	*	*	.	.	*	.	*	*	*	.	.	.	.	†	
Ossiculum (91),	.	.	.	.	*	.	*	.	*	.	*	.	*				
polyhedrum	.	.	.	.	.	.	.	*	.	.	.	.	.	*	*	†	
quadratum,	.	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*
Rajula,	.	.	*	.	.	.	.	.	.	*	.	.	.	*	.	†	
Rectangulum,	.	.	.	.	.	*	*	.	*	*	.	.	.	†			
Rhombus,	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	†	
rostratum,	.	.	.	*	.	.	.	.	.	.	.	.	*	†	.	*	
rude (95),	.	*	*	.	*	*	*	*	*	*	*	*	*	*	*	*	*
Securis,	.	.	*	.	.	*	.	.	*	*	.	.	.	*			
serpentinum,	.	.	.	.	.	.	*	.	*	.	.	.	*	†	.	*	
Serra (82 *a*),	*	*	*	*	*?	*	*	.	*	*	*	.	*	*	†	*	
sinuosum,	.	.	.	.	*	.	.	.	.	.	.	.	.	.			
spinulosum,	.	.	*	.	.	.	.	.	*	.	.	.	.	*	.	†	*
spiriferum (103),	.	.	.	.	*	.	*	.	*	.	*	.	*	*	*	†	
Taurus (82 *b*),	.	.	*	.	*	.	*?	.	.	*	.	.	*?		†	*?	
Terebra (93),	.	.	.	.	.	.	.	.	.	.	.	.	*	*			
Trabecula,	.	*	*	*	.	.	*	.	*	*	.	*	*		*	*	*
Triceros (101?)	.	.	*	*?	.	.	.	.	*	*	.	.	*?	†			
undatum,	.	.	*													†	
unidentatum,	.	.	*?	*	.	*	.	.	.	*	*	*	*	*	.	†	
ventricosum,	.	*	.	.	.	*	.	.	*	.	.	.	.	.	*		
?																	
Spongolithis acicularis,	.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
amphioxys,	.	.	.	.	*										*		
apiculata,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*		
aspera,	*	.	.	.	*	*	.	.	.	.	.	.	.	.	*	†	
Caput Serpentis,	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	†	
cenocephala,	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.		
Clavus,	.	.	.	.	.	.	.	.	.	.	*						
fistulosa,	*?	.	.	.	.	.	.	.	*	*						*	
foraminosa,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Fustis,	.	.	*?	*?	.	*?	.	.	.	*	*	.	*	.	.		
inflexa,	.	.	.	.	.	.	.	.	.	*							
mesogongyla,	.	.	*	*	*												
obtusa,	.	.	*	.	*	*	*	.	.	.	.	.	.	*	*		
philippensis,	.	.	.	.	.	.	.	.	.	*							
robusta,	.	*	*	.	.	*	.	.	.	.	.	.	.	.	.	*	
? (obtusa aspera),	.	.	*	.	.	.	.	.	*							†	
Triceros,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
POLYTHALAMIA.																	
Grammostomum?	.	.	.	.	.	.	.	.	.	*?							
carinatum,	.	.	.	.	.	.	.		.	*?							
——	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†		
Miliola,	.	.	.	.	.	.	.	.	*?	.	.	.	.	*?			
Nodosaria,	.	.	.	.	.	.	.	.	.	.	.	.	*				
Planulina,	.	.	.	.	.	.	.	.	.	*?							

Table II.—*Continued.*

	I.						II.						III.		IV.	V.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	January, 1833.	March 10, 1834.	March 7, 1838.	March 8, 1838.	March 9, '38. A	March 9, '38. B	Italy, 1803.	Udine, 1803.	Calabria, 1813.	Malta, 1830.	Genoa, 1846. A	Genoa, 1846. B	Lyons, 1846.	Tyrol, 1847.	Salzburg, 1847.	Breslau, 1848.	Ireland, 1849.
Rotalia globulosa,	.	.	.	.	.	.	*?	.	.	*	.	.	*?	.	.	.	*
senaria,	.	.	.	.	.	.	*?	.	.	*							
?	.	.	.	.	.	.	.	.	.	*							
?	.	.	.	.	.	.	.	.	.	.	.	.	*				
Spirillina,	.	.	.	.	.	.	.	.	.	*							
Spiro-loculina ?	.	.	.	.	.	.	*	.	.	*?	.	.	.	*			
?	.	.	.	.	.	.	.	.	.	.	.	.	*	†			
Textilaria globulosa,	.	.	*?	.	.	.	.	.	.	*	.	.	*	.	.	†	*
striata,	.	.	.	.	.	.	.	.	.	*?							
? Fragmentum,	.	.	.	.	.	.	*										
?	.	.	.	.	.	*											
?	.	.	.	.	*	*	.	.	*	.	.	.	*				
?	.	*	*														
.	.	*	*														
PLANTARUM PARTIC. MOLLES.																	
Seminulum reniforme læve,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
tuberculosum,	.	.	.	.	.	.	.	.	*							†	
triticei forma,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
constrictum costatum,	.	.	.	.	.	.	.	.	*								
ovatum acutum,	.	.	.	.	.	.	.	.	.	.	*						
Filicis,	.	.	.	.	.	.	.	.	.	.	.	.	.	†			
(Fungi ?) ovatum obtusum,	*	*															
Sporangia (Fungorum ?)																	
disperma,	*															*	
trisperma,	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	†	
4sperma,	.	.	.	*	.	.	.	.	*	.	.	.	*	.	.	†	
5sperma,	.	.	.	.	.	.	.	.	.	.	*	.	*			†	
6sperma,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Phragmidii ?	.	.	.	.	.	.	.	.	.	.	*	.	*				
Epidermis plantæ,	.	.	.	.	*	.	.	.	.	.	.	.	.	*	*	.	*
Parenchymaticæ cellulæ,	.	.	.	.	*	.	.	*	.	.	.	*	*	*	.	†	*
Prosenchymaticæ cellulæ,	.	.	.	.	.	.	.	*									
Cellulæ liberæ,																	
subglobosæ læves,																	
oblongæ læves,																	
dentatæ,																	
Fibra plantæ nodosa,	.	.	.	.	.	.	.	.	*	.	.	.	.	*			
spiralis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*
fibrosa,	*	.	*	*	.	.	*	.	.	.	.	.	.	*	†	†	*
reticulata,	.	.	.	.	.	.	.	.	.	.	.	.	.	†	†	†	
porosa,	.	.	.	.	.	.	.	.	.	.	.	.	.	†			
ocellata (Pini),	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	†	
Denticulus folii marginalis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Pilus plantæ simplex lævis,	.	.	.	.	.	.	.	*	*	.	.	*	*	*	†	†	
asper,	.	.	.	.	.	.	.	.	*	.	.	.	*	†	*	†	
tugidus lævis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
asper,	.	.	.	.	.	.	.	.	.	*						†	
apice spiralis,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
inflexus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
basi turgidus,	.	.	.	.	.	.	*	.	.	*	.	.	.	*			
constrictus,	.	.	.	.	.	.	.	.	*	.	.	.	.	*			

Table II.—*Continued.*

	I.						II.								III.	IV.	V.
	1 January, 1833.	2 March 10, 1834.	3 March 7, 1838.	4 March 8, 1838.	5 March 9, '38. A	6 March 9, '38. B	7 Italy, 1803.	8 Udine, 1803.	9 Calabria, 1813.	10 Malta, 1830.	11 Genoa, 1846. A	12 Genoa, 1846. B	13 Lyons, 1846.	14 Tyrol, 1847.	15 Salzburg, 1847.	16 Breslau, 1848.	17 Ireland, 1849.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pilus articulatus lævis acutus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
obtusus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
asper,	.	.	.	.	.	.	.	.	*								
fasciculatus,	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*		
ornithorhamphus,	.	.	.	*	.	.	.	.	*	.	*	.	.	*		†	
hamatus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
dentatus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
stellatus dichot.,	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
Squamula plantæ radiata,	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
	.	.	.	.	.	.	.	.	.	.	*						
	.	.	.	.	.	.	.	.	.	.	*						
Pollen ? tricoccum,	.	.	.	.	.	.	.	.	.	.	*	*	.	.	*		
? flexuosum,	.	.	.	.	.	.	.	.	.	.	.	.	.	*			
? triquetrum,	.	.	.	.	.	.	.	.	.	.	*						
Pini maius,	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	†	
minus,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Musci frondosi particulæ,	.	*	.	.	.	.	.	.	*?	.	.	.	.	.	.	.	*!
Conferva tenuissima,	.	.	.	.	.	.	*!	.	.	.	.	.	.	.	.	†	
?	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	*!
Ulva,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Particulæ incertæ,	.	.	.	.	.	*											
	.	.	.	.	.	*											
INSECTORUM FRAGMENTA.																	
Antenna (Palpus ?),	.	.	.	.	.	.	.	.	.	*							
Pes,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Lepidopteri alæ squamula,																	
integra,	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	†	
alia,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
5dentata,	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.		
3dentata,	.	.	.	.	.	.	.	.	.	.	.	.	*			†	
Ala Dipteri,	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.		
ANORGANICA.																	
Crystalli columnares.																	
alliaceo virides,	*	.	*	.	.	.	*	*	*	*	*	.	*	*	*	*	
pallide virides,	*	*	.	.	.	.	.	.	.	.	.	.	.	.	*	*	
hexagoni regulares,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
albi,	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	†	
Sem. Tritici forma,	.	*	.	*	.	.	*	.	*	.	*	.	*	.	†		
rubri,	.	.	.	.	.	.	.	.	.	*							
aurantiaci,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
cubici albi (Spathi),	.	.	.	.	.	.	.	.	.	.	.	.	.	*	†	†	
rhomb. albi (Spathi),	*	*	.	.	.	.	.	*	.	*	*	.	.	*	†	†	
Pumiceæ particulæ,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†	
Arena quartzea,	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	184	17	29	43	33	37	31	43	15	50	54	45	16	55	44	32	36	20

ART. XLIII.—*Notice of the Geology of the Florida Keys, and of the Southern Coast of Florida ;* by M. TUOMEY, Prof. Geol., University of Alabama.

DURING the past summer, I paid a short visit to the coast of Florida, with the view of comparing the recent deposits there, with the white limestone of Alabama. This limestone occurs in the latter state in a stratum two or three hundred feet in thickness, composed for the most part of irregular grains of carbonate of lime, sometimes but slightly cohering, but frequently sufficiently hard to fit it for a building material. It abounds in fragments of corals, but the most conspicuous fossil, on account of the vast numbers in which it occurs, is Orbitoides Mantelli. This fossil, so far as I know, is not found east of Alabama, and certainly does not extend into South Carolina. Echinoderms and corals are found in great abundance wherever the white limestone occurs. It has been traced from Mississippi to the Cape Fear river above Wilmington ; throughout the entire distance, whilst the stratum varies in thickness, its mineral composition continues unchanged—a white and nearly pure carbonate of lime. Towards Virginia it becomes more siliceous, the corals and echinoderms disappear, but the other fossils for the most part are identical.

Some specimens of white calcareous mud from Florida, which I saw in the cabinet of my friend, Prof. Gibbes, of Charleston, and which, when dried, presented nearly the same appearance as the white limestone, lead me to suppose that there exists, at this moment, in the Gulf of Mexico, conditions similar to those under which the tertiary white limestone was deposited.

The recent limestone from the West India Islands, so frequently brought as ballast by vessels, is seen on all our wharves, and is familiar to every one ; but I did not know till I reached Key West, that at all the Keys between that and Key Biscayne, the sands on the shore, and the very mud on the bottom of the sea of that region were all calcareous—without even a particle of anything siliceous.

Key West is about six miles in length and two miles wide, the highest point being fifteen or twenty feet above mean tide. The deepest wells are about fifteen feet in depth ; the water in them which is slightly brackish, ebbs and flows with the tide. The explanation of this phenomenon, which is often seen in the wells sunk in the porous strata along our coast, is doubtless found in the fact that the water of the wells is backed up by that of the tide, upon which it floats as we see in our rivers. The rock perforated in these wells, like that everywhere else exposed, is sufficiently soft to yield readily to the axe, with the exception of a thin crust of a few inches on the surface which is

quite hard, especially where it is exposed alternately to the action of the tides and atmosphere. This indurated crust may be seen on the road between the town and the barracks, and around the salt-works. Below this crust the rock is quite soft, and in some other respects resembles the Alabama white limestone; but the most striking difference, next to that of organic remains, consists in the distinctly oolite structure of the Florida limestone. This structure is seen where one would be led to expect it, in the fine-grained seams. A few hundred yards from the hospital a quarry has been opened where the rock may be examined. The organic remains consist of broken shells and water-worn fragments of corals, which, both in species and state of preservation, resemble those on the shores of the island. Except in degree of hardness, the rock does not differ from the calcareous sands thrown up by the waves on the shore in the vicinity; and the conditions presented by the loose moving sands, are not favorable to the habits of molluscous animals, nor are fossil shells very abundant in the limestone of the island. Oblique or false stratification is everywhere seen in the rock, the inclination of the planes differing very little from the slope of the shore up which the waves push dead shells, pieces of coral, &c. After a breeze, coarse materials are found strewing the beach, a light wind leaves a finer deposit, and in the succeeding calm the sea appears milky from fine calcareous matter suspended in the water; this is deposited in the form of free impalpable mud which invests marine plants and other objects, to which it adheres with great tenacity, and becomes a source of annoyance to collectors of Algæ. All these alternations of fine and coarse materials may be observed in the limestone.

Along the south beach, the sand is thrown up by the waves to an elevation nearly equal to that of the highest point of the island, and during the gale of Oct. 1841, the greater part of it was submerged, so that, at first sight, it might appear that the whole island was the result of sand thrown up at such times. But although I observed no beds in the limestone that prove, like those of our tertiary, that the animals whose remains they contain, lived and died on the spot, yet in its structure it shows the result of long continued steady wave-work, that cannot be referred to any such cause. There are, however, on other parts of the coast, evidences of gradual elevatory movements.

On Key West I found in the rocks, no beds of corals retaining their original position, although large fragments are scattered through the mass. Living corals of two or three genera are abundant in the surrounding shallow water.

Some of the small Keys, such as the Mangrove Keys, are the result of gradual deposition of sedimentary matter, many of those interspersed among the larger islands have not yet reached the

level of high water, but are nevertheless covered by a dense growth of this curious tree. It would be difficult to imagine a plant better adapted to island making, than the Mangrove. Its long pendulous seeds fall into the shallow water, stick in the soft mud and take root; the bud proceeding from the opposite extremity, soon shoots up above water and sends down branches almost perpendicularly into the mud, these take root and produce other trees, and so on. Besides these, lateral shoots are given off, and at a distance of three or four feet, enter the water and take root; from the part above water others proceed and take a similar stride, and in this way they often travel twenty or thirty yards from the parent stem. Seaweeds and drift-wood become entangled among the stems, and very soon a permanent island is formed. Such islands are generally found under the lee of the Keys.

But the greater number, if not all, the Keys rest upon a foundation of corals. At Sand Key, large rugged masses of dead coral are seen bordering the Key on the windward side, and rising above low water; similar masses may be seen at Sambo Key and at other places along the outer reef. But the Keys within this barrier present better opportunities for studying the foundation upon which they rest. At Key Vacca corals rise to a height of four feet above high water, and present not the slightest evidence of disturbance, beyond the upward movement which raised them to their present position. The rocky mass of coral along the margin of the Key is undermined by the waves, and otherwise worn into singularly rugged shapes, with sharp projecting points. Even at some distance from the water, bunches of coral project above the surface wherever the overlying sand is washed away.

On Bahia-honda similar appearances are presented, where the coral rocks extend seaward; on the lee of the island, a long sand-bank is thrown up, and a lagoon of considerable extent is formed, in which the mangrove tree is seen striding about in the soft mud. This island was washed in two by the last hurricane, and the channel formed has three feet of water at low tide. In the shallow water off many of the Keys, very beautiful patches of algæ interspersed with living corals, are seen within six or eight inches of the surface. Off Indian and Plantation Keys, dark knobs of coral are visible upon the white mud of the bottom, which render the navigation amongst these keys dangerous. On Lower Matacumba I traced the rugged coral rocks for a mile in extent; I also found them on Conch Key, as I did indeed on nearly every island that I examined, where a section could be found on the shore, from which the overlying sands were washed.

There can be no doubt that this great chain of Keys diverging from Key Biscayne, extending over a distance of one hundred and fifty miles, and having an average breadth of fifteen miles, is

due to the elevation of a vast uneven coral reef whose prominent points rising above the water, form the foundation of the Keys, the sands driven up by the waves having done the rest.

The water between the reef and main land is in many places shallow; the bottom is covered with white calcareous sand and soft mud, and is intersected by tortuous channels. The first siliceous sand that I saw, was dredged up off Soldier Key; from this point it was traced, on the bottom, to Cape Florida, and beyond this towards the north it covers the Atlantic shore.

The adaptation of the Keys and adjoining coast to the production of tropical fruits, is well known in the streets of Key West; the cocoa-nut tree ripens its fruit, yet the absence of soil is quite remarkable; I did not see two acres of land having a depth of soil of three inches, on any of the islands that I visited.

Besides Key West, very few of the Keys are inhabited, so that it was not a little cheering to come upon the stations and signals of the Coast Survey, although operations were suspended at that season.

After examining the limestone of Tampa bay, which I think Mr. Conrad has correctly referred to a tertiary formation older than the miocene, I did not expect to find the main land at the mouth of the Miami made up of beds of limestone of the same age as those I examined at Key West and elsewhere inside the reef. The fossils are all identical with the shells living in the surrounding water.* On both sides of the mouth of the river near Fort Dallas, I found fossils showing on the weathered surface of the rocks; and among them Lucina Jamaicensis, and Pyrula perversa. Like that of Key West, the rock has the appearance of having resulted from sands washed up by the waves.

The Miami is one of the outlets of that vast swamp, the 'Everglades,' it has found a passage through the crescent-shaped dam of limestone which encloses and causes that extraordinary morass. It is about three miles and a half to the first falls where the river emerges from the 'Everglades;' a short rapid is formed, upon which a mill is placed for the manufacture of arrow-root from Coomty, (*Zamia integrifolia,*) a plant that grows abundantly on the ridge surrounding the Glades. The section presented at the falls in every respect resembles that at the mouth of the river, and it is known that the 'Everglades' rest on a vast basin of this limestone. Judging by the eye alone, the ridge through which the Miami flows must be twenty or thirty feet in height; while the Glades are said to be but six or eight feet above tide.

* This fact had been previously pointed out by B. Smith, Esq., in a report to the Secretary of the Treasury in 1848, which I saw after these observations were made.

It seems strange that while so much speculation has been excited in relation to the drainage of this swamp, so few lines of levels have been seen, the only means after all, of settling this important question.

The soil on the margin of the 'Everglades' is composed of vegetable matter and white silicious sand which seems to be washed in by the rains from the ridges.*

The best point for the examination of the limestone of the main land, is at Lewis's Point, a short distance from the mouth of the river; the section is about twelve feet in height, and in a few hundred yards all the characteristics of the limestone are finely presented.

It was curious to observe at this locality the influence of the river on the mollusca. The only oysters that I observed occur here. I found also a Perna, which I do not find recorded among the marine fauna of our coast, although the genus occurs fossil in Virginia and Maryland.

In a limestone so porous and soft as this, the existence of lime-sinks, subterranean streams and natural bridges is not surprising.

What portion of the Peninsula is made up of this very recent formation, I am unable to say, but as I have already stated, it must not be confounded with the tertiary of Tampa which doubtless extends to Charlotte harbor.

The contour of the ridge surrounding the 'Everglades,' taken together with the structure of the rock of which it is composed, and imbedded organic remains, leads very strongly to the conclusion that it once occupied a position similar to that now occupied by the Keys. And it is evident that an elevation of the Keys of about ten or twenty feet would produce a similar ridge, shutting out the sea from the space, at present, between the reef and the main land, and producing a second 'Everglade,' differing from the present only in its greater comparative length.

Tuskaloosa, Feb. 26th, 1851.

Art. XLIV.—*On the Law of the Rotation of the Primary Planets;* by Daniel Kirkwood.

In the American Journal of Science and Arts, for March, 1851, I notice an article by Prof. Loomis, calling in question the truth of the recently discovered analogy in the periods of rotation of the primary planets. The reasons assigned by Professor Loomis for withholding his assent to this law are:—

I. That it gives an improbable period of rotation to Uranus.

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* I have but recently received the species collected, and have therefore had no time for examining them.

II. That the mass, distance and time of rotation of the original planet between Mars and Jupiter, as determined by the law in question, are inadmissible.

III. That the values of the rotation constant for Mars, Jupiter and Saturn are not identical; and

Finally, that the law is incompatible with certain analogies found to exist between the different members of our planetary system. I design in this paper briefly to review these objections in order. The first has the greatest appearance of plausibility, and is therefore entitled to special consideration.

The time of rotation of Uranus, according to my analogy, is about 34 hours. Professor Loomis, on several accounts, regards this period as inadmissible. His first objection is stated as follows:

"Laplace, in the Mec. Cel., vol. iv, p. 356, says, 'the time of rotation of Uranus is not probably much less than that of Jupiter or Saturn,' and in the last edition of Herschel's Astronomy, page 648, the time of rotation is given at 9h. 30m.?"

To this I reply, that Uranus's time of rotation *has never been measured.* Consequently if the first objection is different from the second it has no other foundation than mere conjecture.

The second objection is based on Mädler's determination of the planet's polar compression. But can its rotary velocity be deduced from its figure? Exclusive of Uranus, the oblateness of only four members of our system has been measured: viz., the Earth, Mars, Jupiter and Saturn. The figure of Saturn, it is well known, is not that of a regular spheroid. It was observed by Sir William Herschel that "the flattening of the poles did not seem to begin till near a very high latitude, so that the real figure of the planet resembled a square, or rather a parallelogram with the corners rounded off deeply, but not so much as to bring it to a spheroid." The proportion of the disc, as given by Herschel is

Diameter of the greatest curvature, .	36
Equatorial diameter, ...	35
Polar diameter, ...	32

This figure, it is evident, could not have been produced simply by the centrifugal force due to the planet's rotation. Again, the oblateness of Mars is, according to Arago, eight times, or according to Herschel, nineteen times greater than that of the figure of equilibrium of a fluid having the same variation of density as the earth. In other words, Arago's determination of this planet's polar compression indicates a rotation-period of less than nine hours; Herschel's measurement, less than six hours; and a mean between the two, about seven hours. The true period, therefore, exceeds that inferred from the shape of the planet in about the same proportion as my estimate of Uranus' period

exceeds that of Prof. Loomis. "The singular irregularities in the form of Saturn, and the great compression of Mars," says a distinguished writer, "prove the internal structure of these two planets to be very far from uniform."

While, then, the compression of a planet may be regarded as denoting in general the *fact* of its rotation, it is by no means a reliable indication of its angular velocity. In all probability, a variety of modifying causes, which cannot at present be reached by our analysis, have coöperated in producing the actual forms of the heavenly bodies.

If the planets have undergone a progressive contraction from a state of vapor, their oblateness at former epochs must have been indefinitely greater than at present, and must have varied during the entire process of condensation. The question then naturally presents itself whether the ratio of a planet's diameter to that of its sphere of attraction may not have some connection with its present polar compression. Perhaps it may not be improper to remark that these ratios in the case of Mars and Uranus are about equal, and each very much greater than in any other planet.

I shall now consider the objection that my analogy assigns inadmissible elements to the hypothetical planet between Mars and Jupiter. And first in regard to the mass. Thirteen supposed fragments have been discovered in this region; nine having been detected within the last five years. The dimensions of all are admitted to be extremely uncertain. The apparent diameters of only four,—Vesta, Juno, Ceres, and Pallas,—have been taken; and in regard to these, the measurements of Herschel, Schrœter, and Mädler are very discordant. According to the determination of Schrœter the sum of their volumes is more than equal to one-fourth that of Mars. Adopting this estimate, therefore, and assuming that their average magnitude is equal to that of the remaining nine, the thirteen already discovered would be nearly equal to Mars. It may not be improper to remark in this connection that the apparent brilliancy of the asteroids does not always seem to increase with the magnitude. Pallas, which according to both Mädler and Schrœter, is very much larger than Vesta, appears as a star of the eighth magnitude, while the latter is of the sixth, and has been seen by the naked eye.

But the objection to the mass of the hypothetical planet, even adopting Mädler's values, does not appear to me very important. What is there improbable in the supposition that hundreds or even thousands of asteroids, too small to be detected by our telescopes, may revolve in this mysterious cluster? Indeed, if we may judge from the recent success which has attended the researches of astronomers, it would seem by no means unreasonable to suppose that a number much greater than has yet been observed, may be hereafter discovered.

The great discrepancies, however, in Prof. L.'s estimates result in part from his assuming a period of twenty-seven hours as the time of rotation of "the asteroid planet." His authority for this assumption is the fact that Schrœter from some of his observations supposed *Juno* to complete a revolution in that time. If we admit the correctness of Schrœter's inference (which is doubtful), it can afford no evidence whatever, that the *original* planet revolved in the same or nearly the same period.

In regard to the values of the constant $\frac{n}{D^{\frac{3}{2}}}$, for Mars and Jupiter, it is sufficient to say that by using the received masses of these bodies, and certain values of the mass, distance and time of rotation of the intervening planet, involving no absurdity, they perfectly harmonize with the law of rotation. In the case of Saturn there is no discrepancy worthy of notice.

The objection drawn from the analogies observed in the planetary system may be stated as follows: The eight principle primary planets consist of two distinct classes; the members of each exhibiting "a strong family likeness." Uranus is included in the same class with Jupiter and Saturn; hence the probability that his period of rotation does not differ very much from theirs. The class of minor planets includes Mercury, Venus, the Earth and Mars. Of these the periods of rotation are nearly the same; varying between 23h. 20m. and 24h. 40m. Now "if we suppose the asteroids to have been once united in a single body, probably no one would hesitate to assign it" to the last of these classes.

The argument here urged against the truth of my law, is, that it makes the period of rotation of the original body between Mars and Jupiter, as well as that of Uranus, entirely different from those of all the planets whose rotary velocity has been ascertained. It is a remarkable fact, however, that *in other respects* extraordinary peculiarities in the primitive constitution of those two bodies unquestionably obtained. I refer to the unknown causes which produced the avulsion of the ancient planet, and the anomalous motions of the satellites of Uranus.

Prof. L.'s discrepancy in the values of $\frac{n}{D^{\frac{3}{2}}}$ for Venus and the Earth results in part from his employing Encke's mass of Mercury, confessedly only an approximation. The mass adopted by Prof. Walker is the mean of this value and the first and second masses of Leverrier.

With regard, then, to the *unknown* mass and period of the hypothetical planet, and the rotation of Uranus, discussion would be next to useless. That my formula harmonizes with the *known* elements of the solar system as exactly as even recent determinations of the masses of the planets by different astronomers agree

with each other, is simply a fact which admits of no controversy. We have then at least seventeen* independent variable quantities which harmonize together in a complicated formula. In regard to each of these there are many chances to one against its value being such as to produce the existing harmony; hence the probability is almost infinity to unity against the accidental coincidence of the whole. The conclusion seems irresistible that my formula is the expression of a law of nature.

Pottsville, Pa., March, 1851.

Art. XLV.—*New Genera of Fossil Corals from the Report by* James Hall, *on the Palæontology of New York.*

The researches of Mr. James Hall into the palæontology of New York have been carried forward with great labor and careful investigation, and are an honor to the state under whose liberal patronage and direction they are continued. The region included within the limits of the state, embraces the whole range of the Silurian and Devonian rocks, and in no part of the world is this series of strata more fully developed, or more abundant in organic remains. The completeness of the system here displayed will make it classic ground for the student of the ancient life on our globe, and Mr. Hall's work, in which these relics of antiquity are described, must become of standard importance the world over. The first volume, a thick quarto, with nearly a hundred plates, was published in 1847. A second volume of equal extent has been for some time ready to be issued excepting a few plates yet unfinished. This is hardly half the work before him—although 722 species have been thus far described; for the fossils are strewed through many of the rocks of the state with the most wonderful profusion, and the whole number of species they include cannot be less than 1800. We propose in this place to cite the descriptions of some of Mr. Hall's new genera from the second volume. We confine ourselves at present to the fossil corals. The strata whose fossils are described in this volume, are those of the Medina sandstone, and the following beds to the Onondaga Salt Group; over 200 pages of the volume are devoted to the Niagara Group.—Eds.

New Genera of Fossil Corals.—1. *Clinton Group.*

Genus Helopora, *Hall*, p. 44.—[Bryozoöid?] Simple or branching cylindrical stems, often swelling at the upper extrem-

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* Viz.: The distances and masses of Mercury, Venus, the Earth, Mars, Jupiter, Saturn and Uranus, and the periods of rotation of Venus, the Earth and Saturn.

ity, poriferous on all sides. Pores oval or subangular, arranged between longitudinal elevated lines.—Species *H. fragilis.*

Genus Phænopora, *Hall*, p. 46.—[Bryozoöid.] Corallum consisting of a thin broad calcareous or semicalcareous expansion which is celluliferous on both sides; cellules oval, arranged between direct longitudinal and obliquely transverse lamellæ, and opening upward and outwards from the base. Near Fenestella in general aspect.—Sp., *P. explanata, P. constellata, P. ensiformis.*

Genus Rhinopora, *Hall*, p. 48.—[Bryozöoid?] Corallum consisting of an expanded calcareous crust, either subcylindrical and hollow or explanate, poriferous on the two sides; cells arranged somewhat in quincunx order, roundish or oval, and strongly raised in little papillæ or pustules above the surface.—Species *R. verrucosa, R. tubulosa.*

2. *Niagara Group.*

Genus Polydilasma, *Hall*, p. 112.—Corallum turbinate [Cyathophylloid]; lamellæ numerous, thin, apparently rising in pairs and one often much stronger than the other; cell broad, margin thick and strong, with a deep central pit; half the lamellæ reaching to the centre of the cell, where they are complicated or contorted; transverse septa below the central part of the cup obsolete or irregular. Allied to Calophyllum, but does not show the transverse septa characteristic of that genus.—Sp., *P. turbinatum.*

Genus Conophyllum, *Hall*, p. 114.—Corallum turbinate or subcylindrical, having transverse septa in the form of inverted cones set one within the other; rays or lamellæ very thin, numerous and denticulate. In weathered specimens the transverse septa often project beyond the sides the coral above, and the whole appears somewhat like a series of inverted cones. The weathered surfaces have sometimes the appearance of Cystiphyllum, from the irregular meeting of the upper and under surfaces of the successive transverse septa.—Sp., *C. Niagarense.*

Genus Diplophyllum, *Hall*, p. 115.—Simple; ramose or aggregated cylindrical stems; corallum composed of two distinct portions, the inner transversely septate, the outer with fine transverse dissepiments uniting the lamellæ which are continuous to the centre; cell deeply concave in the centre and separated from the outer portion by a distinct rim. both the inner and outer portions stellate, with the same number of rays. Near the Diphyphyllum of Lonsdale.—Sp., *D. cæspitosum.*

Genus Astrocerium, *Hall*, p. 120.—Coral massive (or ramose?); interior prismatic or basaltiform; cells contiguous, openings upon the surface more or less angular, and often very variable in size; rays twelve or more, consisting of slender elongated and ascending points; transverse septa direct. Near *Favosites*, and more especially, *Favistella*, but with spiniform rays instead

of lamellar.—Sp., *A. venustum*, *A. parasiticum*, *A. pyriforme*, *A. constrictum.*

Genus Cladopora, *Hall*, p. 137.—Ramose or reticulate, branches cylindrical or slightly compressed, terminations terete; coral composed of a series of tubes or cells radiating equally on all sides from the axis, and opening upon the surface in rounded or subangular expanded mouths; cells more or less closely arranged, but not always contiguous and apparently destitute of septa or rays. The cells when filled with calcareous matter frequently separate in prismatic forms like Favosites, but there is no evidence of transverse septa. The cells are not always contiguous, and there is often a space between the cells which appears to be solid in one or more species.—Sp., *C. seriata*, *C. cespitosa*, *C. cervicornis*, *C. fibrosa*, *C. multipora*, *C. macrophora*, *C. reticulata.*

Genus Calopora, *Hall*, p. 144.—Ramose or incrusting with a columnar structure; cells tubular with the apertures circular or petaloid, not contiguous, and having the intermediate spaces occupied by angular cell-like openings which are transversely septate; tubular cells rarely septate.—Sp., *C. elegantula*, *C. florida*, *C. laminata*, *C. aspera*, *C. nummiformis.* The *Hetiopora crassa* of Lonsdale is probably of this genus.

Genus Trematopora, *Hall*, p. 149.—Ramose or incrusting, composed of tubular cells more or less closely arranged; intermediate spaces solid on the surface, but in the interior transversely septate; cells not septate; apertures oval or circular, often contiguous, margined by a thin elevated border or calicle, which on the lower side is often prominent or labellate. Near *Calopora*, but calicle or elevated rim more conspicuous, and intervals between cells solid instead of cellular.—Sp., *T. tuberculosa*, *T. coalescens*, *T. tubulosa*, *T. punctata*, *T. ostiolata*, *T. solida*, *T. striata*, *T. granulifera*, *T. aspera*, *T. spinulosa*, *T. sparsa.*

Genus Striatopora, *Hall*, p. 156.—Ramose; corallum solid; stems composed of angular cells; apertures of the cells opening upon the surface into expanded angular cup-like depressions; interior of the cell rayed or striated, striæ extending beyond the aperture of the cell.—Sp., *S. flexuosa.*

Genus Clathropora, *Hall*, p. 159.—Bryozoöid. Ramose or reticulate; uniformly poriferous on both sides of the reticulate fronds, and on all sides of the stems and branches of ramose forms; apertures of cells more or less quadrangular, regularly arranged in series parallel to the direction of stems, or obliquely in quincunx order. Near Retepora in habit.—Sp., *C. alcicornis*, *C. frondosa.*

Genus Ceramopora, *Hall*, p. 168.—Bryozoöid. Incrusting or in flattened hemispherical forms; cells arranged in alternating or imbricate series; apertures arching or triangular, with the apex

above.—Sp., *C. imbricata*, *C. incrustans*, *C. foliacea.* The *Berenicea irregularis* of Lonsdale, and *B. megastoma* of M'Coy, are here related.

Genus LICHENALIA, *Hall*, p. 171.—Bryozoöid. Membranous or subcalcareous, growing in circular or flabellate forms, concentrically or radiately striate, celluliferous on one surface only; frond usually a thin membrane, though often unequally thickened and contorted or wrinkled. It is only in rare instances that distinct cells are visible, though in most cases the surface appears marked as if by stigmata or the commencement of cells, which sometimes rise in low nodes without presenting any defined apertures.—Sp., *L. concentrica.*

Genus SAGENELLA, *Hall*, p. 172.—Bryozoöid. Thin membranous, net or web-like, incrusting; cells arranged in regular parallel or diverging series more or less oblong quadrangular when in juxtaposition, and separated from each other by a thin lamina of calcareous matter.—Sp., *S. membranacea.*

Genus DICTYONEMA, *Hall*, p. 174.—Bryozoöid, and near Fenestella. Frond circular or flabelliform, composed of slender radiating branches which frequently bifurcate as they extend towards the margin; branches and subdivisions united laterally by fine transverse branchlets; branches impressed with deep striæ or grooves, producing indentations that sometimes have an elongated rhomboidal form; axis subcalcareous with a corneous exterior. Branches sometimes like a graptolite in appearance.—Sp., *D. retiformis*, *D. gracilis.*

Genus INOCAULIS, *Hall*, p. 176.—A plant-like corneous coral with numerous bifurcating branches; structure fibrous or plumose. The texture is like that of Graptolites, a black scaly crust or film being all that remains of the substance. Probably grew in groups of rounded or flattened stems dichotomous above.—Sp., *I. plumulosa.*

ART. XLVI.—*Analyses of Pitchstone Porphyry from Isle Royale, and of a Crystal of Phosphate of Lime from Hurdstown, New Jersey;* by C. T. JACKSON, M.D., Assayer to the State of Massachusetts. (Read before the Boston Society of Natural History, March 19, and communicated to this Journal by the author.)

1. *Pitchstone Porphyry from Isle Royale, Lake Superior.*

Description.—It occurs in rounded pebbles, on the shores of Isle Royale, near Scovill's Point. Color of the pitchstone, jet black, lustre more vitreous than obsidian. Fracture conchoidal. Sp. gr. = 2·375. Hardness 5½. B. B. swells very much, exfoli-

ating and becoming ash grey; at a higher temperature melts into an apple-green blebby glass. The pebbles are porphyritic with crystals of glassy feldspar, and contain occasional amygdules of carbonate of lime, surrounded with a jaspery red crust, and a thin layer of chlorite.

Chemical analysis of the Pitchstone.—The black mineral, carefully picked, was reduced to fine powder by levigation—dried at 212° F., and analyzed in two separate parcels of one gramme each; one for the silica, alumina, lime, manganese, oxyd of iron, and water, and the other for the alkali, with the following results, per cent.

Silica,	67·90
Alumina,	11·20
Peroxyd of iron,	6·40
Lime,	3·10
Oxyd of manganese,	0·80
Soda,	2·61
Water,	8·00
	100·01

These results were verified by repetition on separate portions of the mineral, the water having been distilled in a glass tube and proved to be pure, no organic matter of any kind existing in the mineral, and no alkali but soda.

It is evident that this mineral is analogous to the pitchstone porphyry of the island of Arran, in Scotland; and since it has not, so far as I know, been before discovered in the United States, these results may prove interesting to mineralogists. It is not known, whether it occurs *in place* in the trap rocks, or in the conglomerate which contains the debris of porphyry rocks.

Should I be again called to reëxamine the geology of Lake Superior mineral lands, I shall endeavor to settle this, with other questions, interesting to men of science.

2. *Crystal of Phosphorite from Hurdstown, N. J.*

This crystal had a yellow color, and was remarkably resplendent on the surface like those from St. Lawrence county, New York, appearing as if fire-glazed. Its sp. gr. is = 3·205.

Chemical analysis.—By qualitative analysis, it was first proved to contain fluorine and chlorine, phosphoric acid, lime, oxyd of iron, and manganese.

The fluorine is sufficiently abundant in it to cause deep etching on glass, when it is disengaged by the action of sulphuric acid. Specimens of this etching I exhibited at the meetings of the American Academy of Arts and Sciences last August.

By quantitative analysis, the mineral was found to consist of

Phosphate of lime, ...	92·405
Chlorid of calcium, ...	·540
Peroxyd of iron, ...	·040
Oxyd of manganese, ...	·003
Fluorid of calcium, by difference,	7·012
	100·000

If the oxyd of iron is regarded as protoxyd, it will amount to 0·036 instead of 0·040, but the color forbids its being set down as the protoxyd. The mineral is evidently identical with apatite.

Boston, March 27, 1851.

ART. XLVII.—*On the Volatility of Phosphoric Acid in Acid Solutions when heated; and on Schmidt's Process for the Determination of Nitrogen;* by J. B. BUNCE, of the Yale Analytical Laboratory. Communicated by Prof. J. P. Norton.

1. *On the Volatility of Phosphoric Acid in Acid Solutions.*

ROSE, in a paper upon the determination of phosphoric acid, mentions the volatility of this acid with the vapor of water, when evaporated in an acid solution. The object of the following experiments, was to ascertain the extent of loss which would be suffered in analysis in consequence of this volatility. With this object in view, ·544 grammes of phosphate of soda were dissolved in a gill of water; hydrochloric acid was then added, and the whole evaporated in a water-bath to dryness, being afterwards heated gently to drive off any excess of acid. The residue was treated with strong sulphuric acid, and allowed to stand several hours in order to convert the pyrophosphate of soda into the ordinary tribasic salt. It was then diluted carefully, neutralized by ammonia, and precipitated as ammonio-phosphate of magnesia; the weight of this salt after ignition, was ·0701 grammes, equal to ·045 of phosphoric acid. The consequent loss of phosphoric acid in this experiment was 58·66 per cent. Another experiment in which the chlorine instead of the phosphoric acid was determined, gives as the loss of acid 53·36 per cent.

·2 grammes of phosphate of magnesia and ammonia were next taken, dissolved in hydrochloric acid, diluted until about a gill of fluid was obtained, and the whole was then evaporated as before; after precipitation and ignition, the residue weighed ·1316, corresponding to 41·69 per cent. of phosphoric acid. The per-centage of phosphoric acid in the ammonio-phosphate of magnesia, as determined by ignition, was 48·37 per cent. Consequent loss of phosphoric acid 6·67 per cent.

Another experiment conducted in the same manner, with the exception that the pyrophosphate of magnesia was converted into the tribasic condition, by fusion with carbonate of soda, gave 8·35 per cent. as the loss. The loss of phosphoric acid when the solution was acidified with sulphuric acid instead of hydrochloric acid was greater, probably owing to the higher degree of heat required to volatilize that acid. There was no perceptible difference between the action of hydrochloric and nitric acids. Phosphate of soda was completely converted into the sulphate of the same, by three evaporations with sulphuric acid and water. Phosphates of alumina, iron, lime and magnesia were not perfectly converted into sulphates even by a dozen successive evaporations. Phosphoric acid does not seem to be more volatile in the vapor of alcohol than in that of water.

These experiments serve to show that the ordinary methods of analysis are not applicable to the analysis of phosphates which must be dissolved in acid by the aid of heat. In the ordinary evaporations to separate silica by rendering it insoluble, a very considerable loss of this acid is occasioned. The estimated quantity of phosphoric acid in ashes, &c., must probably in many cases be much too low, owing to this loss from volatilization, and we may believe that for this reason many analyses must be regarded as almost valueless with respect to the amount of phosphoric acid which they indicate.

2. *On Schmidt's Process for the Determination of Nitrogen.*

Chemists engaged in organic analysis have long felt the want of a quick and accurate process, for the determination of nitrogen. Several objections may be offered to the method of Messrs. Will and Varrentrapp—in following which, the substance to be analyzed is burned in contact with soda-lime, the ammonia formed is passed into a solution of hydrochloric acid gas, and after evaporation precipitated as ammonio-chlorid of platinum. The more important of these arises from the solubility of the platinum salt, and the time required for the evaporation, drying, weighing, &c. In Liebig's report for 1847 and '48, mention is made of several new methods for the determination of nitrogen. Of these that of Schmidt attracted my attention and I was led to make some experiments upon it. He burns the substance as in the Will and Varrentrapp process, and passes the ammonia formed into a solution of one part chlorid of barium in eight parts of water: through this a constant stream of carbonic acid is passed, and from the precipitated carbonate of baryta, the nitrogen in the analyzed substance is calculated by equivalents. In experimenting on this process, I burned carefully crystallized ferrocyanid of potassium, which had been proved pure by previous experiment: and I obtained results

differing so widely from each other that I was led to suspect some serious difficulty in the process. It was found upon trial, that carbonate of baryta was partially decomposed by boiling with chlorid of ammonium in a neutral solution, and also that chlorid of ammonium when boiled by itself is converted into an acid salt. This holds true with many of the salts of ammonia with the stronger acids. A solution of chlorid of calcium in alcohol produced no better results. The precipitated carbonate of lime was decomposed by the chlorid of ammonium formed, even in presence of alcohol.

I then tried some of the organic salts. Succinic acid gives with chlorid of barium no precipitate, but upon the addition of ammonia a fine crystalline precipitate is produced, only slightly soluble in water, and insoluble in alcohol. But as succinate of baryta is slightly soluble in ammoniacal salts, it was found that no use could be made of this method.

It would appear therefore that none of these modifications are capable of affording accurate results, and that the original process by Schmidt, unless some very essential feature is omitted in our account of it, must be considered faulty.

ART. XLVIII.—*On Bromine as a Toxicological agent;* by HENRY WURTZ, Assistant in the Yale Analytical Laboratory.

I HAVE not found in the various toxicological writings any suggestion as to the use of bromine for destroying the organic matter of stomachs. Nevertheless, the unparalleled intensity of its action upon organic tissues, together with the convenience of its use, seem to give it some advantage over the ordinary agents used for this purpose.

An experiment to this effect was made upon a human stomach sent to this laboratory for examination.

The entire stomach with its contents, in the same state in which it was sent, was introduced into a porcelain dish, covered with water, and about an ounce of bromine poured in, which had been previously ascertained to be free from any other substance of a poisonous nature.

A gentle heat was now applied, much below the boiling point of water, and the stomach was turned over from time to time with a glass rod.

(Especial care should be taken that this operation be performed in a strong draught, because the action of the bromine vapors upon the lungs and eyes is injurious beyond the ordinary belief. In case of accidental injury from this cause, the best antidote is inhalation of chloroform or ether.)

When the stomach had completely disappeared, which took place in less than half an hour, some hydrochloric acid was added and the heat continued for a few minutes longer. The liquid was now ready for filtration and left upon the filter only a few flakes of organic matter, together with a little fat and that portion of the contents of the stomach which was insoluble in hydrochloric acid. It may be here noticed that a piece of paper which had been improperly wrapped around the stomach by those who sent it, and which could not be separated from it, also a cotton string which had been tied around it by the same parties, were also completely destroyed by the bromine.

In the filtrate, arsenic, antimony, mercury, etc., were searched for by the usual methods.

To preclude all fear of fallacy in this process, I may add that an experiment was made to ascertain whether the volatility of the bromids of arsenic, antimony, and mercury could influence the result.

A liquid which contained just detectable traces of arsenious acid, tartar emetic and corrosive sublimate, was evaporated to dryness in the presence of a large excess of bromine. In the residue were still easily detected arsenic, antimony and mercury. This result does not, of course, touch the question whether arsenic and antimonic acids are volatilized like phosphoric acid, by evaporation of their acid solutions, either without decomposition or as terbromids or quinquibromids of arsenic and antimony, the decision of which would require many special experiments.

In fact, the experiments of Dupasquier, which have an indirect bearing upon this question, show that *arsenious acid* when evaporated in the presence of a large quantity of hydrochloric acid, may be entirely volatilized, probably as terchlorid of arsenic.* Dr. Wolcott Gibbs recently informed me that he has had occasion to confirm this observation of Dupasquier.

The boiling points, however, of the terbromids of arsenic and antimony are quoted at 428° and 518° F., respectively, while the chlorids of the same metals boil at 270° and 446° F., which facts evidently render the chance of loss in the bromine process less than in the old processes.

Art. XLIX.—*On an Improved Remontoire Escapement for an Astronomical Clock;* by J. Fulton.

If a simple pendulum, vibrating seconds in a very small arc, is made to describe any of the arcs in the following table, the daily loss will be according to the extent of the arc made on each side of the point of rest, as shown there.

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* Gmelin's Handbuch, ii, 709.

Arcs described on each side	Inches and decimal parts.	Daily loss.
0° 15′	0·165	0·1 sec.
0 30	0·337	0·4
1 0	0·674	1·6
2 0	1·349	6·6
3 0	2·024	14·8
4 0	2·699	26 3
5 0	3·374	41·1

By inspecting the above table, taken from Reid's work, on Clock and Watch making, page 153, it may readily be inferred that any cause producing a change in the extent of the arc of vibration, will cause a change in time. Now, as practical difficulties prevent the use of a cycloid arc, in which long and short vibrations would be equal in time it becomes a matter of importance to adopt such measures as will cause the pendulum to keep one regular arc of vibration, without increase or diminution.

For this purpose, remontoire escapements have been tried, in which the weight, through the train of wheels, is made to lift a small weight, or bind a spring, and this again to communicate impulse to the pendulum. But I believe they have not been found effectual on account of the great amount and consequent inequality of friction, in the unlocking of the teeth of the scape wheel, which has to be performed by the pendulum.

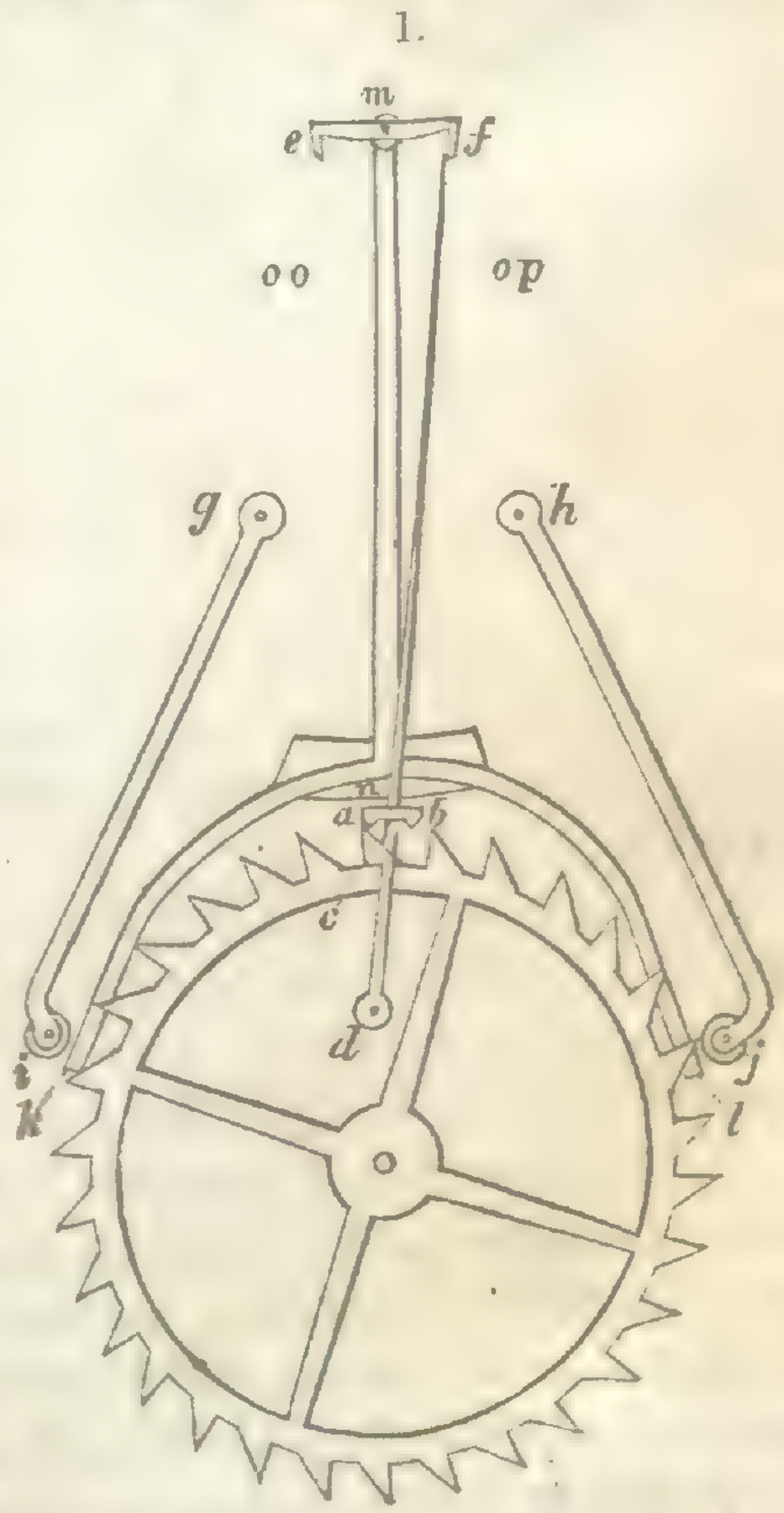
It occurred to me some years since that it would be possible so to reduce the friction in the unlocking of a remontoire escapement, as to leave the pendulum almost entirely to its free natural motion, which being kept up by equal impulses, would be always in equal arcs. With this end in view I contrived an escapement, which I have brought through various stages of improvement; and now respectfully offer to the public as here set forth.

(The plates, weight, train of wheels, &c., up to the scape wheel may be as in other clocks.)

Fig. 1.—*k a b l*, the scape wheel.

a b, pair small pallets with pivots at *c*, and lever *d f* on the same arbor, but broken away about the arbor to show the pallets.

1.

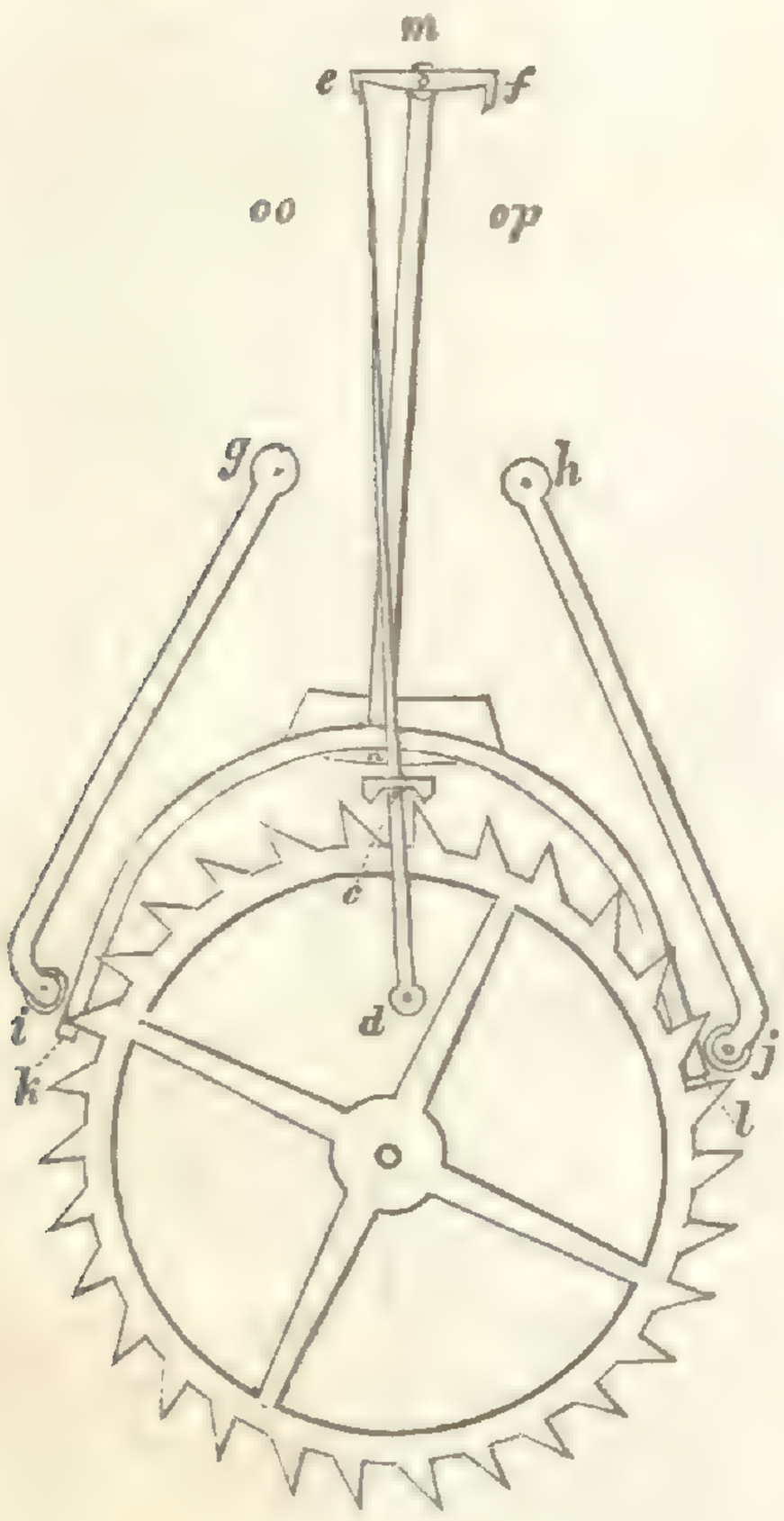


g i and *h j*, two remontoire weights, with pivots at *g* and *h*, and rollers at *i* and *j*.

m n, the pendulum guide, with two arms *n k* and *n l*, extending down to reach the rollers of the remontoire weights.

e f, pair locking pallets attached to the arbor of the pendulum guide, to lock the lever *d f*. (The axis *m* of the pendulum guide coincides with that about which the pendulum vibrates.)

2.



3.

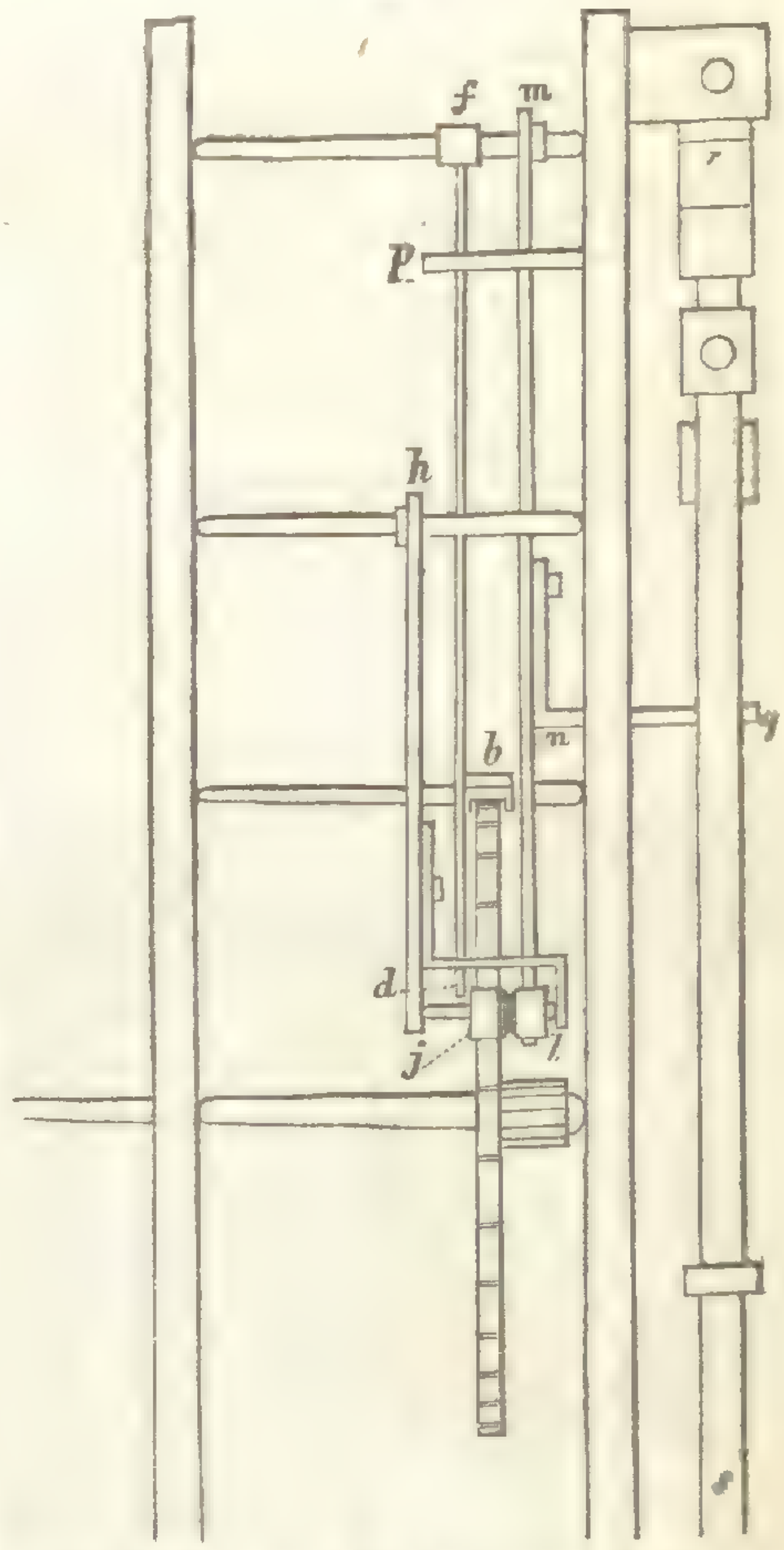


Fig. 3 shows a side view; *r s* part of the gridiron pendulum; *n q* the fork of the pendulum guide passing through an aperture in the plate. The other letters show the same parts as in figs. 1 and 2.

Fig. 1. It will be seen that, as the wheel is urged forward in the direction *a b*, the pressure of a tooth against the inclined plane of the pallet *a*, would cause it to move out of the way, if the lever *d f* were not held by the pallet *f*.

As the pendulum vibrates from left to right, the pressure of the remontoire weight *i*, against the arm *k* of the pendulum guide, communicates impulse to the pendulum till the roller lodges against the wheel, between two teeth; but just before the roller touches the wheel, the arm *l* will come in contact with and lift the roller *j*, from the point of the tooth on which it rests: and

by the same motion the lever will be unlocked from the pallet *f* by the time the roller *j* is fairly out of the way of the wheel; at which time the pressure of the tooth against the inclined plane of the pallet *a*, will cause the lever to move toward and strike against the pin at *p*; when the tooth will escape from the pallet *a*; the wheel will move forward half the distance between two teeth, and raise the roller *i*, till it rests on the point of the tooth; a tooth will come in contact with the inclined plane of the pallet *b*, and cause the lever to move toward and lodge against the pallet *e*, as seen in fig. 2, where it will remain till the pendulum completes its vibration; and when it returns from right to left, the remontoire weight *j* will give impulse to the pendulum, till it lodges against the wheel behind the tooth on which it formerly rested, as seen, fig. 2; the arm *k* will raise the roller *i*, from the point of the tooth on which it will find it; immediately the lever will be freed from the pallet *e*; the pressure of a tooth against the pallet *b*, will cause the lever to strike the pin at *o*; the tooth will escape from the pallet *b*, and the wheel will move forward half the distance between two teeth, raising the roller *j* to the point of the tooth; a tooth will come against the pallet *a*, fig. 1, and cause the lever to lock against the pallet *f*: the pendulum, after completing its vibration, will again proceed to the right, and the same movements will be repeated.

If in fig. 1, the distance from the pallet *a* to the fulcrum *c*, is one-twelfth of an inch, and the length of the lever from *c* to *f* is three inches; the pressure of the lever against the pallet *f* will be only about one thirty-sixth of the pressure against the pallet *a*. Now, if in connection with this we remember that the distance *m f*, is much shorter than the distance from *m* to *i*, the point where the unlocking would be, if made from the scape wheel, we may readily conclude that the resistance to the pendulum in this unlocking is almost nothing compared with that in other escapements.

In the above specification I have endeavored to avoid all unnecessary minuteness; but perhaps it will not be amiss farther to observe that the lever *d f* should be extremely light, and accurately balanced on its pivots. The pallets *a b*, should be half the distance between two teeth apart, and on opposite sides of their axis. The axes of the remontoire weights should be placed in straight lines passing from the axis of the pendulum guide and touching the points of the teeth of the scape wheel, and far enough apart to allow room for the lever *d f* to play between its bankings. The diameter of the rollers should be equal to about two-thirds of the distance between two teeth. If oil is to be used on the pallets *a b*, it would be well to turn a crease around the center of the roller as shown in fig. 3. When the wheel raises a remontoire weight, it should stop before the tooth comes

quite up to a line drawn from the center of the roller to the center of the wheel. The pendulum guide should be as light as possible, that there may not be much friction at its pivots. I think everything farther necessary, and perhaps much that has been said, would readily suggest itself to any skillful workman that might undertake to execute an escapement on this principle.

I have a more simple form of this escapement, which gives impulse to every second beat of the pendulum in operation in a time-piece, with half seconds pendulum which performs extremely well. But I suppose the form giving impulse both ways would be preferred for an astronomical clock, as the second hand will mark seconds, and the beats will be equal and will sound alike.

This escapement is susceptible of being used to compensate for the expansion and contraction of the pendulum rod by change of temperature. If the remontoire weight, instead of stopping against the wheel, were made to stop against an apparatus of brass and steel soldered together, which in warm weather would not allow it to descend as far as in cold, the pendulum would take a shorter arc in warm, than in cold weather, which would tend to neutralize the effect of its expansion. How accurate it might be made I am not prepared to say: it would require the pendulum to vibrate in pretty wide arcs. Perhaps the principle might be used with advantage in turret clocks in connection with the form of escapement giving impulse in only one direction, which has but one remontoire weight.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Experimental Researches in Electricity;* By Michael Faraday, Esq., D.C.L., F.R.S., &c.—(Proc. Roy. Soc., Phil. Mag., 4th Ser. i. 68.)—(1.) Twenty-fourth Series.—*On the possible relation of Gravity to Electricity.*—Under the full persuasion that all the forces of nature are mutually dependent, and often, if not always, convertible more or less into each other, the author endeavored to connect gravity and magnetic or electric action together by experimental results, and though the conclusions were, when cleared from all error, of a negative nature, he still thinks that the principal followed and the experiments themselves deserve to be recorded. Considering that some condition of the results produced by gravity ought to present itself, having a relation to the dual or antithetical character of the magnetic or electric forces, it seemed to the author that the approximation of two gravitating bodies towards each other, and their separation, were the only points which offered this kind of coincidence; and therefore, using the earth as one gravitating body, he employed a cylinder of metal, glass, resins, or other substances, as the other, and endeavored to ascertain when the latter was allowed to

fall, being surrounded by a helix of wire, whether any electric current was generated. Sometimes the cylinder was allowed to fall through the helix; at other times with the helix; and occasionally the helix was made the falling body. But when the various sources of error which sprung up were gradually removed, no traces of electric action remained which could be referred to the power of gravity.

In order to obtain a greater effect, an apparatus was employed (being nearly that used in the 23rd Series of these Researches) by which the effect of raising a body from the earth could be combined with that of a falling body by the fit use of commutators (if any action at all were produced). The apparatus was very good, and gave exceeding delicate results, as was shown by other consequences of its action; but in respect of gravity it produced no effect whatever. Notwithstanding his failure in obtaining any experimental relation between gravity and magnetic or electric force, the author still expresses his conviction that there is a relation, and his hopes that it may be hereafter practically demonstrated.

(2.) Twenty-fifth Series.—*On the Magnetic and Diamagnetic Condition of Bodies.* Received September 9, 1850.—As the author could find no polarity in diamagnetic bodies when under magnetic influence (a result described in the 23rd Series of these Researches), he endeavored to discover some other physical condition of them, and of magnetic bodies, by which he might obtain an insight into their respective natures, and establish the true place of the magnetic zero; and considering the power with which a magnetic body moves, or tends to move, from weaker to stronger places of action, and that of a diamagnetic body to pass from stronger to weaker places of action, he hoped to obtain some results of condensation with the first class, and of expansion with the second, when they were subjected to very strong magnetic action; the respective bodies being selected from the class of gaseous substances, in which change of volume can be easily produced and measured. In the first place, therefore, a ray of light was passed over the surface of powerful magnetic poles surrounded by different gases, and the place of its source carefully examined by telescopes, micrometers, and other means, to ascertain whether the layer of air in contact with the poles was affected in its refracting force; but though the experiment was made in oxygen, nitrogen, and other gases, not the slightest effect was visible.

Resigning this process, therefore, two air-tight chambers were made, in which the magnetic poles formed the chief part of the internal surface of the chamber. The one was formed by bringing the flat ends of the two poles to within $\frac{1}{60}$th of an inch of each other, with a frame all round to form the sides; and the other by cutting away the central parts of an iron cylinder so as to give it the form of an hour-glass, and then enclosing that part by an air-tight copper tube. Cocks were attached to these chambers for the introduction and removal of gases, and for the application of gauges which were able to indicate a change of volume equal to the $\frac{1}{100000}$th part of the contents of the chamber. When any given gas was introdued into the chamber, and the latter then placed between the poles of the electro-magnet, any possible alteration of volume would be shown by the gauge as soon as the mag-

net was rendered active ; but whatever gas was employed, or whatever power of magnet used, not the slightest change was produced.

Thinking it possible that there might be expansion in one direction and contraction in another, the gases were then examined as to the production of any currents in them, but no traces of such appeared.

From these results, the conclusion was arrived at by the author, that the motions of magnetic and diamagnetic bodies in each other do not appear to resemble those of attraction or repulsion of the ordinary kind, but to be of a differential action, dependent perhaps upon the manner in which the lines of magnetic force were affected in passing from one to the other during their course from pole to pole ; the differential action being in ordinary cases between the body experimented with and the medium surrounding it and the poles. A method of showing this action with the gases is described, in which delicate soap-bubbles are made to contain a given gas, and these when held in the magnetic field, approach, or are driven further off, according as they contain substances, magnetic or diamagnetic, in relation to air. Oxygen passes inwards or tends toward the magnetic axis, confirming the results formerly described by the author in his account of his investigations of flame and gases.

Perceiving that if two like bubbles were set on opposite sides of a magnetic core or keeper cut into the shape of an hour-glass, they would compensate each other, both for their own diamagnetic matter and for the air which they would displace ; and that only the contents of the bulbs would be virtually in a differential relation to each other, the author passed from bubbles of soapy water to others of glass ; and then constructed a differential torsion balance to which these could be attached, of the following nature :—A horizontal lever was suspended by cocoon silk, and at right angles, at the end of one arm, was attached a horizontal cross-bar, at which, about $1\frac{1}{2}$ inch apart, and equidistant from the horizontal lever, were suspended the glass bubbles ; and then the whole being adjusted so that one bubble should be on one side of the iron core and the other on the other side, any difference in their tendency to set inwards or outwards from the axial line caused them to take up their places of rest at different distances from the magnetic axis ; and the power necessary to bring them to an equidistant position became a measure of their relative magnetic or diamagnetic force.

In the first place, different gases were tried against each other, and when oxygen was one of them that went inwards, driving every other outwards. The other gases when compared together, gave nearly equal results, and require a more delicate and finished balance to measure and determine the amount of their respective forces.

The author now conceived that he had attained to the long-sought power of examining gaseous bodies in relation to the effects of heat and the effects of expansion separately ; and proceeded to an investigation of the latter point. For this purpose he prepared glass bubbles containing a full atmosphere, or half an atmosphere, or any other proportion of a given gas ; having thus the power of diluting it without the addition of any other body. The effect was most striking. When nitrogen and oxygen bubbles were put into the balance, each at one atmosphere, the oxygen drove the nitrogen out powerfully. When the

oxygen bubble was replaced by other bubbles containing less oxygen, the tendency inwards of the oxygen was less powerful ; and when what may be called an oxygen vacuum (being a bulb filled with oxygen, exhausted, and then hermetically sealed) was put up, it simply balanced the nitrogen bubble. Oxygen at half an atmosphere was less magnetic than that at one atmosphere, but more magnetic than other oxygen at one-third of an atmosphere ; and that at one-third surpassed the vacuum. In fact, the bubble with its contents was more magnetic in proportion to the oxygen it contained. On the other hand, nitrogen showed no difference of this kind ; whether a bubble contained that gas more or less condensed, its power was the same. Other gases (excepting olefiant and cyanogen) seemed in this first rough apparatus to be in the same condition. The air-pump vacuums of all the gases were alike, including that of oxygen.

Hence the author decides upon the place for zero, and concludes that simple space presents that case. When matter is added to space it carries its own property with it there, adding either magnetic or diamagnetic force to the space so occupied in proportion to the quantity of matter employed ; and now thinking that the point of zero is well determined, he concludes to use the word magnetic as a general term, and distinguishes the two classes of magnetic bodies into paramagnetic and diamagnetic substances.

There is no other gas like oxygen ; its paramagnetic character is very high. A solution of protosulphate of iron in distilled water was prepared, of which a certain bulk in a glass bubble was of the same paramagnetic force as an equal volume of oxygen ; the solution was then of such strength as to contain of crystallized protosulphate of iron seventeen times the weight of the oxygen which could counterbalance it. In another case, a glass bubble, containing one-third of a cubic inch of oxygen, was opposed to a corresponding bubble having within only an oxygen vacuum. As soon as the magnetic power was on, the oxygen passed inwards, and it required a force equal to one-tenth of a grain to hold it out at the equidistant position.

The author then refers generally to the air as a paramagnetic medium, because of the oxygen it contains, and in the next, or Twenty-sixth Series of Researches, he proposes to enter, after some preliminary inquiries, into the great subject of atmospheric magnetism.

(3.) Twenty-sixth Series.—*On Magnetic Conducting Power and Atmospheric Magnetism.* Received October 9, 1850.—The remarkable results respecting oxygen and nitrogen described in the last Series, and the absence of any change of volume under strong magnetic action, led the author to apply for a time the idea of conducting power to the magnetic phenomena there described, meaning by that phrase the capability which bodies possess of affecting the transmission of the magnetic force without any reference to the process by which that transmission is affected ; and assuming that two bodies are at the same time in the magnetic field, and that one displaces the other, he considers the result as a differential effect of their difference in conducting power.

If a free portion of space be considered with lines of equal magnetic force passing across it, they will be straight and parallel lines. If a sphere of paramagnetic matter be placed in such a space, they will

gather upon and in the sphere, being no longer parallel in their course nor of equal intensity in every part; or if a sphere of diamagnetic matter replace the former sphere, the lines of force will open out where the sphere is, being again no longer parallel in direction nor uniform in force. When the field of magnetic force is formed between the opposite flat ends of two large magnetic poles, then these are affected, and the globes also, and there are mutual actions; a paramagnetic body, if a little elongated, points axially and tends to go to the iron walls of the field, whilst a similar diamagnetic body points equatorially, and tends to go to the middle of the field. Paramagnetic bodies repel each other, and so also do diamagnetic bodies; but one of each class being taken, they attract one another.

The convergence of the lines of force upon the opposite sides of the paramagnetic sphere, and the corresponding divergence of them on the opposite sides of the diamagnetic sphere, the author expresses by the term *conduction polarity*. This polarity he carefully distinguishes from that which depends upon the reversion of the direction of the power; the latter he considers as a property of the particles of magnetic matter; the former as dependant rather upon the action of the mass; the latter is an absolute inversion of the direction of the power, the former only a divergence or deflection of it.

Applying the idea of conduction to magnecrystallic bodies, he concluded that the magnecrystallic axis would coincide with the direction of better conduction, and thence concluded, that, if a symmetric crystal of bismuth were carefully examined in different directions, it would be found to be less diamagnetic when its magnecrystallic axis was perpendicular to the axis of magnetic force of the field in which it was to be submitted to experiment, than when it was parallel to the magnetic axis. By means of the differential torsion balance described in the former paper, he was able to make the trial, and found the results were as anticipated. With calcareous spar and his present balance he was not able to establish any difference, but concludes that it will prove most diamagnetic when the optic axis of the crystal and the magnetic axis of the field are parallel.

Advancing to the consideration of atmospheric magnetism, the author first refers to the earth as a source of magnetic power from which emanate lines of magnetic force passing into space according to a particular but recognized distribution, and in obedience to the general laws which govern the distribution of power about a given irregular magnet. In pure space the magnetic power is considered as transmitted onwards with a certain degree of facility which is constant, but may be increased or diminished by the presence of paramagnetic or diamagnetic matter within that space. The atmosphere is a portion of such matter, and can affect the magnetic lines which pass from the earth into space, and affects them differently according to variations which continually occur in it under natural circumstances. Four-fifths nearly by volume of the air is nitrogen, which is a gas that neither under any difference of temperature or of expansion shows any alteration in its power of affecting the transference of the magnetic force; whether added to space therefore in one state or another, or when undergoing changes of a corrresponding kind by natural cause, it has no influence

on the magnetic force. The perfect identity in magnetic action of hot and cold nitrogen, the author proves by new and delicate experiments. Oxygen forms the remaining fifth of the atmosphere. Its great magnetic changes by expansion have been described in the Twenty-fifth Series. Those produced by difference of temperature were described in the Philosophical Magazine for 1847, but are now resumed with more care, and found to belong to it alone, and not to nitrogen or carbonic acid; as its temperature is raised its paramagnetic force diminishes, being resumed as the temperature falls again. These properties it carries into the atmosphere, so that the latter is in reality a magnetic medium ever varying, from the influence of natural circumstances, in its magnetic power. If a mass of the air be cooled it becomes more paramagnetic, if heated it becomes less paramagnetic (or diamagnetic,) as compared with the air in a mean or normal condition.

The effect of the approach and retreat of the sun in his daily course is to produce such variations of changes in the temperature and expansion of the atmosphere as to influence the lines of force emanating from the earth, both in their direction and intensity; and the manner in which this influence will be developed is by means of figures and descriptions stated by the author in relation to the annual and daily variation, and the irregular perturbations of the magnetic force, which he thinks are consequences of it. He then applies the result of the magnetic observations at Hobarton as a test of the probable truth of the hypothesis, and considers that it affords strong confirmation. The upper or north end of the needle there goes west until about twenty-one o'clock, whilst the dip increases; the dip still increasing until noon, the upper end returns rapidly eastward, as the sun passes by, until two o'clock, the dip then decreasing; after which the needle goes west again, following the sun. On examining the results at Toronto, corresponding effects were found to occur, when the upper or south end of the needle was considered, and therefore in accordance with the hypothesis. The examinations of the observations made at Greenwich, Washington, Lake Athabasca, Fort Simpson, and St. Petersburgh, are considered as adding further confirmation. By the aid of these observations the author restates his principles more minutely, endeavoring to indicate what difference, changes in the inclination, declination, place of the sun, land, and sea, &c., will produce.

Though the sun is the cause of those changes in the atmosphere which affect the lines of force of the earth, he is not assumed as the centre of action as regards those lines; that is considered to exist somewhere in the atmosphere. It appears to be in the upper regions and not on the surface of the earth, because it increases the dip of places north and south of the tropics which have a certain amount of inclination, as at Hobarton, and Toronto, both in summer and winter, but it diminishes the dip at places which are within the tropics, and with little inclination, as St. Helena. By other kinds of observations, it appears to be in advance of the sun. All the phenomena indicate that the sun does not act directly on the needles at different places, but mediately through its effect on the atmosphere.

The author then considers the possible cause of numerous irregular variations, such as those that are shown by the photographic processes

of record at Greenwich and Toronto. The varying pressure of the atmosphere, the occurrence of winds and large currents of air, of rain and snow, of the passage of those masses of warm and cold air which the meteorologist recognizes in the atmosphere, of the aurora borealis, he considers may all produce changes in the lines of magnetic force, and become more or less sensible in the records of irregular variations. The author thinks it very possible that masses of air at different temperatures may be moved by the magnetic force of the earth, according to the principles of differential action made manifest in the experiments on warm and cold oxygen, in which case material as well as potential magnetic storms may exist. He concludes his paper by calling attention to the wonderful constitution of oxygen in its magnetical and electrical, as well as its chemical relations, to the offices it has to perform as part of the atmosphere.

(4.) Twenty-seventh Series. *Atmospheric Magnetism continued.* Received November 19, 1850.—In order to obtain an experimental representative of the action of the atmosphere when heated above or cooled below the average temperature, the author employed a ring helix of covered copper wire, through which an electric current was passed. The helix was about one inch and a half in diameter, and having the well-known system of magnetic forces, was placed with its magnetic axis parallel to a free needle; when its position was such that a needle within the ring would point with the north end downward, then the effect in deflecting the surrounding lines of force of the earth was considered as like that of a relatively paramagnetic mass of air; and when its position was reversed, its action was representative of that of a heated or relatively diamagnetic mass of air. Bringing this helix into the vicinity of small magnetic needles, suspended either freely, or so as to show declination or inclination, the planes of action or indifference as regards the power of deflecting the lines of force and the needle were observed. When the needle can move only in one plane, there are four quadrants, formed (in the case of the declination needle) by the intersection of the planes of the magnetic equator and meridian. When in these planes there is no deflection at the needle, but when in the quadrants there is, and in opposite directions in the neighboring quadrants.

As the lines of force are held in and by the earth, so these experiments were repeated with a needle in near vicinity to a magnet, and the difference of effect is pointed out; then the extent to which these results are applicable to those of the earth is considered, and their utility in guiding the inquirer.

The effect of heated air having been considered in the last paper, that of cold air is now taken up; and after considering its action in causing a contraction or drawing together of the terrestial lines of magnetic force, according to the principles of conduction before enunciated, the author considers generally where the regions of cold which travel round the earth every twenty-four hours will be in the northern and southern hemispheres, and how they will grow up and diminish in extent and importance as the sun moves north and south during the year. After which he applies these considerations, and the result of the experiments with the ring helix, to the explication of the changes of the needle as

they are given by observations at St. Petersburgh, Greenwich, Hobarton, Toronto, Cape of Good Hope, St. Helena and Singapore. In doing this, he endeavors to explain the night action, the early morning effect, the contrary course of the needle for the same hours in different months, the difference of local time dependent on the distribution of land and water, the cumulative effect of preceding months, and the continual effect, especially in the tropical regions, of the higher temperature of the northern hemisphere above that of the south. In all these points the author sees such an agreement between the natural results and those which are suggested by the assumed physical cause of the magnetic variations, as to give him a growing confidence in the truth of the views he has put forth.

2. *Daguerrotypes by Galvanic Light;* by B. SILLIMAN, Jr.—In 1840, in company with Dr. W. H. GOODE, I showed the possibility of taking impressions on an iodized silver plate by the light of a powerful voltaic pile. An account of our trials on that occasion was published in this Journal, first series, vol. xliii, p. 185.

Since that time my attention has not been called to the subject, until lately, when the arrival at the Louisville Laboratory of one of Duboscq's regulators of the galvanic light by an electro-magnet, suggested the propriety of repeating the experiment. The battery employed in 1840 was the extensive series of 900 pairs of zinc and copper all plunged at one movement, and which instrument is still (as then) in the laboratory of Yale College. The light from this arrangement was very intense, the arc of flame about four inches at the first instant but of course inconstant as well from the nature of the pile as from the absence at that time of any contrivance like that of Duboscq for its regulation.

The battery employed in the present trials was composed of fifty pairs of Bunsen's carbon battery made by Deleuil of Paris. Although very powerful, it could not be at all compared with the 900 members of the old arrangement in its initial effect, but this defect is more than compensated in its constancy. Our first trial was to make a copy of Thorwaldsen's Venus in plaster, placed at a distance of about twenty feet from the focus which was made in a large parabolic mirror with a silver surface. The camera was placed at about the same distance from the figure in such a position as to secure a favorable image. The plate was prepared with the usual sensitive coating of bromid of iodine, and the experiment was continued through about two minutes. The result showed that the relative distances of the light, the figure, and the instrument were not properly adjusted. An impression was produced but it was faint and required a longer exposure than usual to the vapor of mercury to develop it.

It was afterwards found better to bring the figure within about twelve feet of the light and also to approach the camera somewhat nearer. With this modification excellent impressions were procured in forty seconds—and it was the conviction of Mr. Stancliffe, the excellent daguerreotypist in Louisville, and who kindly aided me in these experiments, that even half that time would answer, as nearly all our plates were a little 'solarized,' if that term may be used in reference to galvanic light.

Our trials were not confined to inanimate objects, but good portraits of my friends and assistants, Mr. Brush and M. Dangiville, were also secured, in about one minute each. In the use of this light, care is required to avoid the deep shadows which are not relieved as in sunlight by natural reflecion, and unless attention is paid to this circumstance, the impression appears disfigured by shadows of almost inky darkness.

Practically these trials may be considered of minor importance especially in the United States, where a fine sun-light may be obtained almost any day. But in the dark and murky atmosphere of London, it may become an important auxiliary in the art. Considering the easy manipulation of a good carbon pile, its constancy and the facile management of the light with the ingenious but simple apparatus of Duboscq, it certainly offers a tempting field of investigation as well to the practical daguerreotypist as to the student in optics. It is much more intense and equally manageable with the lime light, and consequently may be substituted for it in all optical demonstrations. Whether the properties of galvanic light are in all respects similar to solar light remains also an interesting question for future investigation.

Laboratory of Louisville University, February, 1851.

3. *Attraction of Electro-magnets.*—Dub has published the results of an elaborate investigation of the attractive forces exerted by electro-magnets upon armatures of different dimensions and placed at different distances from the magnet. The method of measurement employed was similar to that made use of by the author in a previous investigation, and consisted in observing in each case the weight necessary to tear the armature from the magnet itself, when the two were in actual contact, or to hold the attracting force in statical equilibrium when this was not the case. The magnets employed were straight cylindrical bars; the armatures similar bars of various dimensions attached successively to the arms of a balance, and held in exact equilibrium by weights placed in the opposite scale pan; the apparatus was so arranged that the perpendicular distance between the opposing faces of the magnet and the armature could be varied at will and accurately measured. The galvanic circuit employed consisted of a Grove's battery, a tangent's-compass, a rheostat, and the helix of the electro-magnet itself. The author sums up the results which he has obtained in the following terms.

(1.) The attraction diminishes very rapidly with the distance from the magnet.

(2.) The diminution of the attraction is greater in proportion as the attraction itself is small when the attracting surfaces are in contact, the surface of contact remaining the same.

To give a definite idea of the absolute amount of this diminution, the author states that in no one of his experiments was there an attracting force which at a distance of $\frac{1}{150}$ of an inch was greater than half or less than one-fourth of the attraction during contact.

(3.) After a certain distance, the attraction is less in proportion as the magnet or the armature or both are thinner. (Although in general the attraction is not directly proportional to the diameter of the magnet or armature.)

(4.) Pointed armatures and magnets exhibit at a distance less attraction than cylinders of the same diameter.

(5.) The attraction of armatures and magnets of equal diameter increases (in contact or at a distance) with their lengths.

(6.) With magnets and armatures of equal weight, the attraction diminishes more slowly in proportion as these are shorter and thicker.

(7.) After a certain distance armatures of equal mass are equally attracted.

(8.) Magnets of equal weight have an equal attractive force at a distance, when, with the same galvanic effect, the spiral surrounds the magnet throughout its whole length.

(9.) With an equal surface of contact, magnets and armatures attract equally both when in contact and at a distance.

(10.) The attraction is proportional to the square of the number of windings of the electro-magnetic spirals.

(11.) The attractions are proportional to the squares of the magnetizing currents.—(Law of Lenz and Jacobi.)

(12.) The attraction increases with the proximity of the whole number of spiral windings to the surface of contact, up to a certain limit. This limit lies very near the surface of contact.

(13.) The attraction increases more when the spiral remains the same and only the iron core is made longer, than when in making the core longer the same number of windings is spread out over the whole length of the core.

(14.) With the same magnitude of contact surface, the attraction remains the same at a distance, when it is the same while in contact, whatever form the magnet and armature may have.

(15.) The attraction remains the same when the diameters of the magnet and armature are interchanged.

(16.) The attraction remains the same when the armature is made the magnet and the magnet the armature, (provided that the spiral, with the same galvanic effect, surrounds the iron core throughout its whole length.)

(17.) In different systems of equal length and equal diameter, the maximum attraction takes place when the armature and the magnet are of equal length.—*Pogg. Ann.*, lxxx, lxxxi, 494, 46.

4. *On the Amid compounds of Cyanogen.*—Cloez and Cannizzaro have studied the products of the action of gaseous chlorid of cyanogen upon ammonia. When the chlorid is passed into an ethereal solution of the alkali, chlorid of ammonium is formed and separated, while a new substance remains in solution, and may be obtained by distilling off the ether in a water-bath. This new substance the authors term Cyanamid, and as thus prepared it is a white crystalline body, fusing at 40°, but sometimes remaining liquid much below that temperature, in this case however, it instantly solidifies on being touched with a pointed glass rod; its formula is $Cy\,NH_2$. Heated to 150°, cyanamid presents a remarkable phenomenon; the fused mass suddenly solidifies with evolution of great heat; the new substance thus produced, possesses the same constitution as cyanamid itself, but its properties are different and so strongly resemble those of melamine that the authors are disposed to regard it as identical with this substance, and consequently to

consider melamine as the amid of cyanuric acid, so that it results simply from tripling the equivalent of cyanamid; its formula should then be $Cy_3 (NH_2)_3$. Cyanamid is inalterable in dry air; water dissolves it readily, but if the solution be evaporated a residue is obtained nearly insoluble in water and apparently identical with cyanuramid; cyanamid is also soluble in alcohol and ether without change, but alkalis decompose it; with acids it gives crystalline compounds not yet examined. The volatile bases of Wurtz, and many other organic alkalies yield similar compounds when treated with chlorid of cyanogen; the authors have obtained cyano-methylamid, cyanethylamid, and cyanamylamd, represented by the formulas, $Cy\ C_2H_4N$, $Cy\ C_4H_6N$, $Cy\ C_{10}H_{12}N$. The properties of these substances are not yet described, neither is it stated whether there exists a class of isomeric cyanuramids as would appear highly probable.—*Comptes Rendus*, xxxii, 62.

5. *On Cinchonine.*—The constitution of cinchonine has been so differently represented by different chemists as to render it probable that these differences had their origin in an actual diversity of chemical constitution in different specimens of the alkali. Hlasiwecz has carefully investigated the whole subject anew and has found that commercial cinchonin contains two different substances which may be separated from each other by repeated crystallization. The first of these substances possesses all the properties of what is usually described as cinchonine: it crystallizes in moderately large prisms, yields chinolin by distillation, and partially sublimes as a crystalline wool: its formula was found to be $C_{40}H_{24}N_2O_2$, which is the formula given by Regnault. The platinum salt of this base is however represented by the formula $C_{38}H_{22}N_2O_2H_2Cl_2+2Pt\ Cl_2$, according to which it must have lost the elements of C_2H_2; the crystals obtained by sublimation have the same formula. The second substance crystallizes from the mother-liquor of the cinchonine in beautiful rhomboidal crystals; on heating, these become opaque and fuse to an amorphous mass, but do not sublime; analysis gave the formula $C_{20}H_{12}NO_2$, which is the same as that of β chinin found by Heijningen in commercial chinoidine: the author terms this base cinchotin. Commercial cinchonine contains also a brown basic resin which appeared to be identical with chinoidine; a second variety of commercial cinchonine gave the formula originally proposed, by Liebig, $C_{20}H_{11}NO$.—*Ann. der Chemie und Pharmacie*, lxxvii, 49.

6. *Aldehyde of Caprinic Acid.*—Wagner has studied the action of ammonia upon the oil of rue, which the researches of Gerhardt and Cahours had shown to consist principally of an oxygenated oil having the formula $C_{20}H_{20}O_2$ and capable of being readily converted by oxydation into caprinic acid, $C_{20}H_{20}O_4$. When oil of rue is dissolved in alcohol, and a current of ammonia passed into the solution, a white crystalline substance is obtained which exists only at low temperatures and at 0° is resolved into ammonia and oil of rue. Wagner considers this substance to be homologous with aldehyd-ammonia and to have the formula $C_{20}H_{20}O_2, NH_3$. When the new aldehyd-ammonia thus formed is dissolved in alcohol, a current of sulphurous acid passed through the solution, and the whole exposed to a low temperature for several days, a voluminous mass of crystals is obtained resembling margaric acid; these crystals are insoluble in water, soluble in boiling alcohol,

and decomposed by a gentle heat. The author regards this compound as homologous with Redtenbacher's bisulphite of aldehyd-ammonia, and as having the formula $C_{20}H_{20}O_2, NH_3+2SO_2$. Indications of the existence of a homologue of thialdin were also obtained.—*Journal für praktische Chemie*, **1851.** 1, **43.**

7. *Theory of the formation of Ether.*—At the late meeting of the British Association at Edinburgh, a paper was read by A. Williamson upon this subject which deserves particular attention. When the compound of ether and potash, C_4H_5O+KO, obtained by treating absolute alcohol with potassium is gently warmed with iodid of ethyl, iodid of potassium and *ether* are formed, the reaction being represented by the equation,

$$C_4H_5O, KO+C_4H_5I=KI+2C_4H_5O.$$

If in place of iodid of ethyl, iodid of methyl be employed, a similar reaction takes place and a liquid is obtained having the empirical formula, $C_6H_8O_2$: iodid of amyl in like manner yields a new liquid boiling at 110° C., and represented by the formula $C_{14}H_{16}O_2$. Williamson considers these new liquids as alcohols and employing Gerhardt's notation, represents the former by C_3H_8O, the latter by $C_7H_{16}O$. The formation of common ether in the reaction given above he explains by supposing that the true formula of wine alcohol is $C_2\,{}^{H}_{H}{}^{5}\,O$, of its potash compound $C_2\,{}^{H}_{K}{}^{5}\,O$, and that ether results simply from the substitution of one eq. of ethyl for one eq. of hydrogen or potassium, the eq. of oxygen being the same in water, alcohol and ether. Pursuing this idea still farther, Williamson has succeeded in obtaining several other compounds analogous to those already mentioned, and has shown that the order of replacement is indifferent, since alcohol with iodid of methyl yields the same liquid as wood-spirit with iodid of ethyl. The physical and chemical properties of the new liquids are to form the subject of a special memoir; the author contents himself at present with applying the facts already ascertained to the explanation of the formation of ether by the action of sulphuric acid upon alcohol. In order to do this it is in the first place assumed that the formation of sulpho-vinic acid, $C_4H_5O.SO_3+HO.SO_3$, always precedes that of ether and that sulpho-vinic acid is formed by the replacement of one atom of hydrogen in sulphuric acid by one atom of ethyl; in the author's notation, $SO_4\,{}^{H}_{H}+C_2\,{}^{H}_{H}{}^{5}\,O=SO_4\,C_2\,{}^{H}_{H_5}+{}^{H}_{H}O$. The formation of ether then ensues simply by the substitution of one atom of ethyl for one of hydrogen precisely as in the case of the potash compound above mentioned, we have namely the equation

$$\frac{C_2\,{}^{H}_{H_5}\,SO_4}{C_2\,{}^{H}_{H_5}\,O} = \frac{\overline{H}\,SO_4}{C_2\,{}^{H_5}_{H_5}\,O}$$

The sulphuric acid thus set free acts upon a new portion of alcohol to form sulpho-vinic acid and thus the process is continuous. The formation of ether by the action of chlorid of zinc upon alcohol may

be explained in a similar manner.—*Phil. Mag.* [3], xxxvii, 350, and *Ann. der Chemie u. Pharmacie, Jan.*, 1851, lxxvii, 37.

[NOTE.—According to the theory of the constitution of alcohol now almost universally adopted by chemists, the results obtained by Williamson are to be explained by supposing that one eq. of oxyd of ethyl is capable of uniting with one eq. of oxyd of methyl to form a compound in which one of these two oxyds performs precisely the same function as the water in ordinary alcohol. The formula of the new substance must therefore be $C_4H_5O+C_2H_3O$. Williamson considers it inconceivable that the replacement of one eq. of hydrogen in wine alcohol by one eq. of ethyl should give rise to ether, if we admit that alcohol consists of ether in combination with water, and in support of his position he urges that the replacement of the same eq. of hydrogen by an eq. of methyl ought to yield simply a *mixture* of the oxyds of ethyl and methyl and not a chemical combination of the two. This argument falls to the ground, however, when we consider that *difference* in the bodies combining is absolutely essential for *chemical* combination, and that we know of no one instance in which two molecules of the same kind unite chemically; it is therefore easy to see why two molecules of ether brought under favorable circumstances into contact with each other, unite mechanically. The numerous cases of isomerism with which we are acquainted do not furnish arguments in favor of Williamson's position; we have no reason to suppose that cyanuric acid, for example, is a chemical compound of three equivalents of cyanic acid. It can hardly be doubted, however, that the replacement of hydrogen by organic radicals in the manner described will lead to the discovery of the true molecular structure of a vast number of organic compounds which have hitherto baffled investigation. The acetone series for example may possibly prove to be aldehydes in which an eq. of hydrogen is replaced by an eq. of methyl, ethyl or other similar radical; common acetone may perhaps be aldehyde in which an eq. of hydrogen is replaced by an eq. of methyl, and may be obtained by the reaction expressed by the equation $C_4H_4O_2+C_2H_3I=C_6H_6O_2+HI$. W. G.]

8. *On the theory of anisol and its homologues.*—The researches of Williamson on the replacement of the hydrogen of the alcohols by the radicals methyl, ethyl, amyl, &c., have led Cahours to examine the action of the iodids of these radicals upon the compound of potash and oxyd of phenyl represented by the formula $C_{12}H_5O+KO$. When phenol-potash and iodid of methyl are exposed together in a sealed tube to a temperature of from 100° to 120°, double decomposition occurs and the results are iodid of potassium and *anisol*. The reaction in this case is represented by the equation

$$C_{12}H_5KO_2+C_2H_3I=C_{14}H_8O_2+KI.$$

With iodid of ethyl and phenol-potash a similar reaction occurs and phenetol is formed; with iodid of amyl a new compound is formed which the author terms phenamylol. The formation of phenetol and phenamylol may be represented by the equations

$$C_{12}H_5KO_2+C_4H_5I=C_{16}H_{10}O_2+KI$$
$$C_{12}H_5KO_2+C_{10}H_{11}I=C_{22}H_{16}O_2+KI.$$

Phenamylol is a limpid colorless liquid, lighter than water, having an agreeable aromatic odor and boiling at 224°–225° : nitric acid readily attacks it and transforms it into a heavy oil, which by the action of an alcoholic solution of sulphid of ammonium yields a new base which the author calls phénamylidine nitrique.—*Comptes Rendus*, xxxii.

NOTE.—From the investigation of Cahours it appears evident that anisol is to be regarded as phenol in which one eq. of hydrogen is replaced by one eq. of methyl, or more correctly as a compound of oxyd of phenyl and oxyd of methyl, $C_{12}H_5O+C_2H_3O$. This fully explains the remarkable fact to which Kolbe* has directed attention, that the boiling point of anisol is lower than that of phenol with which it appears to be homologous. It also explains why anisol, which possesses the constitution of the alcohol of benzoic acid, does not yield this acid when treated with oxydizing agents. The writer of these notices had, long before the appearance of Cahours' researches, unsuccessfully attempted the production of benzoic acid by the oxydation of anisol; the cause of his failure is now evident; the true homologue of phenol, the alcohol of benzoic acid, remains to be discovered. W. G.

II. MINERALOGY AND GEOLOGY.

1 *Notices of Minerals and new localities*; by Prof. O. P. HUBBARD, Dartmouth College. (Communicated for this Journal.)—(1.) *A large group of Quartz crystals*, now in Dartmouth College cabinet, was obtained many years since, from a cavity in the quartzite of Moose mountain, seven miles east from the college. It is fourteen inches high and wide and two feet long. The crystals are clear and vitreous, though not transparent. Some of the vertices were injured by the iron bar in extracting the mass. There are forty-eight crystals, some of which are six inches long, and they have the following dimensions.

4	**crystals**	**each**	**5**	**to**	$5\frac{1}{2}$	**inches**	**in diameter.**
10	"	"	**4**	"	$4\frac{3}{4}$	"	"
12	"	"	**3**	"	$3\frac{1}{2}$	"	"
7	"	"	**2**	"	$2\frac{3}{4}$	"	"
5	"	"	**1**	"	$1\frac{3}{4}$	"	"
10	"	"	$\frac{3}{4}$			"	"

(2.) *Quartz* in prismatic crystals with double pyramids from one to three inches long, and half an inch and more in diameter, are found in Benton, N. H., near Amos Wheeler's, on a mountain belonging to Daniel Howe. They occur abundantly in the earth where a vein has decomposed. Mr. Amos Wheeler speaks of "a vein of crystals two feet wide in limestone?" from which he brought me handsome implanted crystals though in a different gangue, and he describes a vein of black crystals near by.

(3.) Another locality of *quartz* is Mr. Ball's farm, Beaver meadow, Sharon, Vt.

Here the crystals are dug from the loose soil. They are beautifully clear and transparent, with one perfect termination only, the crystals

* Ann. der Chem. u. Pharmacie, lxxvi, 61.

having been obviously implanted by the other. One of the specimens I have seen is six inches long by two and a half inches diameter.

(4.) *Gray Staurotide* in crosses at 90° and imperfect prisms occurs abundantly in light colored mica slate, in Grantham, about two miles from Meriden village.

The single crystals have a dark red rhombic center, surrounded by a gray exterior, and the angles of the inner and outer prisms do not agree in quantity.

Staurotide, Grantham, N. H.

The compound crystals have a composition like fig. 2 in Dana's Mineralogy, with a modification only on the obtuse solid angles.

(5.) *White Staurotide*, with similar modifications, has been brought me from an unknown locality.

(6.) *Chrysoberyl.*—This rare mineral occurs in the granite of Orange summit, at the deep cut of the Northern Railroad, in a very thin vein. A few specimens were found in the fragments of rock thrown out in making the cut. The forms are like the compound varieties figured in Dana's Mineralogy from Haddam, though without regular terminations.

(7.) *Beryl from Acworth.*—This crystal in the College cabinet has no peculiar beauty to distinguish it from other large specimens from the same locality, but it is remarkably regular in its hexagonal form, and also in size. Its diameter is $13\frac{3}{4}$ inches; height 14 inches; weight 114 lbs., or 96 lbs. to the foot of length, and thus larger than any other reported in the country. Another prism of a somewhat triangular form which I obtained from Grafton, is 16 inches in diameter.

(8.) *Kyanite from Thetford, Vt.*—On the road from the Ompompanoosuc river, north, along the east side of Thetford hill, kyanite occurs in veins or beds of quartz in mica slate, running parallel with the strata which dip west. At the surface the kyanite is reduced to very thin layers of little value, appearing as if the veins with the rock had been much abraded. Large grouped bladed crystals of fine blue and white colors, in specimens 16 inches across, were obtained from loose masses.

(9.) *Chrysolite.*—I am able to announce to mineralogists the discovery of this mineral in masses several inches in diameter. This is believed to be the first notice of its occurrence in North American mineralogy, east of the Rocky Mountains, and a more complete account will be given in a future number of this Journal.

Minerals from India.—(1.) *Apophyllite.* From Rev. Mr. Burgess, Am. missionary at Ahmednugger, India, I have received unusually large crystals of Apophyllite an inch in diameter, with the terminal solid angles deeply replaced.

(2.) *Natrolite* from the same region, in hemispheres seven inches in diameter, also in sectors of three inches radius and of the most beautiful lustre and whiteness.

(3.) *Quartz*, also, with the two last from the trap of the Deccan. The specimen is a stalactite three inches in diameter with a chalcedonic center, having the exterior entirely covered with crystals of quartz terminating in 3-sided pyramids.

Hanover, New Hampshire.

2. *Boulders Carried by Ice*, (Perley's Report on the Fisheries of New Brunswick, p. 26).—Off the western part of Shippagan Island, within the Bay of Chaleur, there is an extensive shallow flat, extending nearly two miles from the land, called the *Grand Batture*. On this flat, there are numerous large blocks or boulders firmly imbedded, which render it dangerous to cross, even with a fishing boat; the wreck of a fishing boat was noticed upon it when the writer crossed in his canoe. These boulders are brought over from the wild and mountainous shores of Caspe, directly across the bay, by the huge masses of floating ice, driven over by the northerly gales which ground upon the *Grand Batture*, and there melting, add the rocks they bring, to those already deposited. With reference to this moving of rocks by ice, Mr. Wilson mentioned that there was formerly a very large rock directly in front of his landing place, at Miscow, which was much in the way of his boats, and against which, in stormy weather, they had often received damage. But the severe winter of 1848–49, caused the ice to attain an unusual strength and thickness near the shore of Miscow: and when it moved off in the spring, it carried off this large rock to deposit it where, he hoped, it would be less troublesome.

III. Zoology.

1. *On the Classification of the Maioid Crustacea or Oxyrhyncha*; by James D. Dana.—The Maioidea are usually divided into three tribes, characterized by the relative lengths of the legs, viz., the *Macropodinea*, the *Maiinea*, and the *Parthenopinea*. A character of the kind here alluded to is of little importance as a distinction in classification, unless it is indicative of other more fundamental differences. The third of these subdivisions seems to be properly and distinctively a natural group. But the first two are essentially identical in all points, excepting the greater or less elongation of the eight posterior legs. The mouth, the antennæ, eyes, branchiæ, and other parts, afford no ground for separating them: moreover, the transitions are gradual and numerous. Libinia and Doclea pass into one another through Libidoclea, and these three genera are more closely related than Doclea and Inachus. Eurypodius contains a species with short legs; and the genus Oregonia, very near Eurypodius, has no longer legs than some of the admitted Maiinea. The mere length of the legs, if regarded, thus breaks up true natural groups.

De Haan sustains the separation of the Inachidæ (Edward's Macropodinea, Doclea and Latreillia being excluded,) on other grounds, acknowledging the unimportance of the characteristic derived from the legs. As in other departments of Crustacea, he basis his distinctions mainly on the maxillæ or maxillipeds. Thus his Maia, Pisa and Doclea groups include species having the fourth joint of the outer maxillipeds articulated with the inner apex of the third joint; while in his Inachus group, the articulation is with the summit of the third joint. This distinction would separate the intimately related genera Eurypodius and Oregonia, as this joint in the latter has the ordinary Maia form. On examining Eurypodius it is found that the peculiarity of the third joint referred to arises simply from its being lengthened or extended along the inner

side, so that the true apical margin slopes backward and outward. The fourth joint is articulated with the same part normally in both, and the only difference is in the greater or less inclination of the summit margin, when greatest it approximating to longitudinal. The little importance of the distinction based upon the maxillipeds among the Cancroidea as well as Maioidea is shown by numerous instances. Even the single genus Xantho presents wide variations, as the joint may be either transverse or oblong. (Compare Xantho Orbignii, *Edw.* with other species.) The system of De Haan for this reason, although developing some new relations, contains many ambiguities and incongruous associations, notwithstanding the learning of its author, the remarkable skill and accuracy of his work, and the vast additions of facts he has made to the science. We have admired the wonderful fidelity of his plates, the thorough spirit of investigation displayed through his magnificent volume, and the judgment with which he has seized upon typical forms in instituting his genera. Yet we can not but object to his defective system of arrangement and description, by which his types are often thrown into wrong associations, and the groups they typify are laid down with false limits,—the characters to be derived, (as the system of Milne Edwards illustrates,) from organs of real importance in the species, being sacrificed in a great degree to indications from the maxillæ or maxillipeds.

In the distribution of the Maioidea, we disregard, for the reasons stated, the older subdivisions of Macropodinea and Maiinea, and arrange their species into families and subfamilies as below, according to the characters of the eyes, antennæ and other organs, using these characters, in the order, as far as we can judge, of their relative bearing upon the functions or habits of the species.

De Haan has separated on good grounds *Latreillia* from the other genera, having shown that the posterior legs are short, dorsal, and more or less prehensile, as in Dromia, and that the vulvæ have the same position as in that genus (in the base of the feet of the third pair); and he therefore places the genus in the Dromia group. Still, in the number of branchiæ and some other characters, it is like the Maiinea, and it is properly an intermediate type. The outer antennæ are peculiar in being free and cylindrical from the very base, with the second joint much longer than the first, nearly as in the Dromiacea. These last facts with regard to the antennæ are also true of another genus having the posterior legs prehensile, somewhat Dromia-like, although they are not at all dorsal and also resemble the preceding legs. The genus referred to is *Oncinopus* of De Haan. It is apparently intermediate in character between the Maia tribe and Latreillia.

The aberrant form, Oncinopus, (and also Latreillia, if it be not thrown with the Dromiacea,) will naturally belong to a distinct group, and we therefore divide the Maioid Crustacea into three tribes, MAIINEA, ONCINEA and PARTHENOPINEA.

The Parthenopinea have the basal joint of the outer antennæ usually filling a hiatus in the orbit, as in most Cancroidea, and not projecting beyond the eyes, besides being more inward and posterior in position, and free or bounded laterally by sutures; while in the Maiinea this joint lies directly below the eye, projects beyond it, and is commonly soldered to the shell outside of the joint. The Parthenopinea are thus intermediate

between the Maiinea and the Cancroid Crustacea, resembling the latter also in their short epistome. The greater length of the anterior legs is not a necessary characteristic. They are also intermediate between the Maiinea and Dromioid species. The genus Trichia, of which De Haan makes one of his grand divisions of the Brachyura, is most nearly related to the Parthenopinea—the orbits, and antennæ, epistome and general form of the body resembling the same in Parthenope. But in its maxillipeds it approaches Dromia, as shown by De Haan.

Telmessus of White appears to belong with the Corystoidea, as the outer antennæ, in connection with the form, indicate.

The following are the Families, Subfamilies and Genera of MAIINEA with their characteristics:

FAM. I. MAIIDÆ.

OCULI RETRACTILES, IN ORBITIS SESE LATENTES.

1. DIGITI ACUMINATI.

A. Carapax oblongus.

α. OCULI PLUS MINUSVE TRANSVERSIM PORRECTI.

α ANTENNÆ EXTERNÆ APERTÆ.

* *Rostrum sive elongatum sive breve, porrectum, non tumidum.*

† Pedes 8 postici prælongi.

1. INACHINÆ.—Carapax triangulato-ovatus. Rostrum emarginatum aut integrum.

G. 1. INACHUS, *Fabricius.*—Carapax gibbosus, spinâ præorbitali sive parvulâ sive nullâ, rostro brevi. Pedes 8 postici filiformes, 2dis 3–4-plo longioribus quam carapax post-rostralis.

G. 2. EGERIA, *Latreille.*—Carapax gibbosus, orbiculato-ovatus, rostro sat brevi, paulo reflexo. Pedes 8 postici filiformes longissimi (iis *Inachi* duplo longiores).

G. 3. MICRORHYNCHUS, *Bell.**—Carapax gibbosus, latitudine transorbitali parvâ, dente præorbitali nullo, post-orbitali parvulo. Rostrum parvulum, integrum. Pedes 8 postici corpore fere duplo longiores.

2. MACROCHEIRINÆ.—Carapax latè ovatus. Rostrum furcatum. Pedes prælongi. Articulus antennarum externarum 1mus solutus.

G. MACROCHEIRA, *De Haan.*†—Carapax gibbosus, orbiculato-ovatus, spinâ præorbitali parvulâ, rostro saliente, cornubus valde divaricatis. Pedes toti validi longi.

†† Pedes 8 postici longitudine mediocres.

† *Pars antennarum externarum mobilis margine orbitæ orta.*

3. MAIINÆ.—Carapax orbiculato-ovatus, rostro prominente, profundè bifido.

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* Zool. Trans., ii, 40.

† Crust. Fauna Japonica, 88.

G. Maia, *Lamarck.*—Articulus antennarum ext. 1mus spinis duabus longis apicem externum armatus. Spina inter-antennalis elongata, acuta. Tarsus infra non spinulosus.

‡‡ *Pars antennarum externarum mobilis orbitâ omnino exclusa.*

4. PISINÆ.—Carapax triangulato-ovatus, rostro bifido.

1. Pedes 8 postici non valde compressi ; articulus 5tus processu infra non armatus.

G. 1. Paramithrax, *Edwards.*—Carapax gibbosus, rostro elongato. Oculi graciles. Articulus antennarum externarum 1mus spinis duabus longis apicem externum armatus (eoque *Maiæ* affinis).

G. 2. Pisa, *Leach.*—Carapax elongatè pyriformis, gibbosus, spinâ præorbitali saliente, rostro longo, vix depresso. Articulus antennarum ext. 1mus angustus. Pedes 2di 3tiis valde longiores.

G. 3. Pelia, *Bell.**—Carapax elongatè pyriformis, gibbosus, spinis præorbitali et post-orbitali carens, rostro longo, vix depresso. Articulus antennarum ext. 1mus angustus. Pedes 1mi 2dis breviores.

G. 4. Lissa, *Leach.*—*Pisæ* affinis. Carapax pyriformis, rostro longiusculo, cornubus laminatis, truncatis, dente præorbitali saliente.

G. 5. Rhodia, *Bell.*†—Carapax pyriformis, paulo depressus, spinâ præorbitali saliente, rostro brevi, acuto. Articulus antennarum externarum 1mus angustus, apicem acutè productus extus unidentatus. Pedes 1mi 2dis breviores.

G. 6. Hyas, *Leach.*—Carapax ovatus, sæpe lyratus, depressus, spinâ præorbitali carens, rostro longiusculo, acuto, depresso. Articulus antennarum ext. 1mus angustus, 2dus depressus, tarsus infra non spinulosus.

G. 7. Pisoides, *Edw.* et *Lucas.*‡—*Hyadi* affinis. Carapax latè ovatus, spinâ præorbitali carens, postorbitali parvâ, rostro longiusculo, acuto. Articulus antennarum ext. 1mus latissimus, 2dus depressus, densè ciliatus.

G. 8. Herbstia, *Edwards.*—Carapax orbiculato-ovatus, depressus, spinâ parvâ præorbitali instructus, rostro brevi, cornubus paulo depressis acutis. Articulus antennarum ext. 1mus angustus, apicem acutè productus, extus uni-dentatus. Pedes 1mi 2dis longiores.

2. Pedes 8 postici late compressi.

G. 10. Thoe, *Bell.*§—Carapax late ovatus, rostro parvulo, bifido, dente præorbitali saliente. Oculi breves. Articulus antennarum ext. 1mus latissimus. Pedes 1mi *maris* 2dis longiores.

3. Articulus pedum posticorum 5tus processu infra armatus.

G. 11. Dehaanius, *M'Leay.*‖—*Hyadi* paulo affinis. Carapax latus, spinâ præorbitali saliente, rostro sat brevi. *Leucippæ* affinis, si oculi non retractiles.

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* Zool. Trans., ii, 35.

† Zool. Trans., ii, 43.

‡ Crust. D'Orbigny's South America 10, pl. 5. The species P. tuberculosus appears to be the Hyas Edwardsii of Bell, Zool. Trans. ii, 49.

§ Zool. Trans. ii, 47.

‖ M'Leay, Smith's Illust. Zool. S. Africa.

** *Rostrum saliens, porrectum, tumidum, apice emarginatum.*

5. LIBININÆ.—Carapax latè pyriformis, tumidus, lateribus altis. Oculi perbreves. Pedes sive mediocres sive prælongi.

G. 1. LIBINIA, *Leach.*—Pedes mediocres. Carapax dente præorbitali parvulo instructus. Abdomen *maris feminæque* 7-articulatum. Articulus antennarum ext. Imus latiusculus, extus non dentigerus.

G. 2. LIBIDOCLEA, *Edw.* et *Lucas.**—Pedes longi. Carapax spinis plus minusve armatus, dente præorbitali parvo. Articulus antennarum ext. 1mus angustus, apicem acutè productus, extus dentigerus.

G. 3. DOCLEA, *Leach.*—Pedes prælongi. Carapax spinis plus minusve armatus, dente præorbitali carens. Articulus antennarum ext. 1mus angustus, abdomen *maris* 7-articulatum, *feminæ* 5–7-articulatum.

*** *Rostrum breve, latissimum, bilobatum, porrectum.*

6. PRIONORHYNCHINÆ.—Carapax ovatus, gibbosus. Oculi breves, Fossæ antennales marginem frontalem fere attingentes.

G. PRIONORHYNCHUS, *Hombron* et *Jacquinot.*†

**** *Rostrum latum, valde deflexum.*

7. MICIPPINÆ.—

G. MICIPPA, *Leach.*—Oculi longiusculi. Carapax anticè parce angustior, rostro laminato.

β ANTENNÆ EXTERNÆ SUB ROSTRO CELATÆ.

8. CHORININÆ.—Carapax triangulato-ovatus. Rostrum furcatum. Pedes 8 postici vix compressi.

G. 1. CHORINUS, *Leach.*—Carapax gibbosus, spinis plus minusve armatus, rostro longo, cornubus acuminatis, spinâ præorbitali saliente. Margo orbitalis inferior largè interruptus. Articulus antennarum ext. 1mus angustus. Pedes 2di 3tiis valde longiores.

G. 2. CHORILIA, *Dana.*‡—Carapax formâ rostroque *Chorino* affinis. Orbita infra latè interrupta, supra fissa, spinâ præorbitali acutâ. Articulus antennæ externæ 1mus angustus, apice externo acutè producto. Pedes 1mi 2dis breviores, 8 postici similes, 2di 3tiis non multo longiores.

G. 3. LAHAINA, *Dana.*§—Carapax formâ rostroque *Chorino* plerumque affinis. Cornua rostri gracillima valde divaricata. Articulus antennæ externæ 1mus latus, parce longior quam latior, apice cum processu spiniformi armato. Orbita infra supraque sinu rotundato interrupta, dente præorbitali acuto. Pedes toti graciles.

G. 4. NAXIA, *Edwards.*—Carapax gibbosus, rostro mediocri, cornubus subcylindricis, truncatis, dente præorbitali brevi. Margo orbitalis inferior fissus, non late interruptus. Articulus antennarum ext. 1mus latus, apicem angustus.

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* Crust. D'Orbigny's South America, 6. pl. 3.
† Voy. Astrolabe et Zelée au pole Sud, pl. 1. f. 1.
‡ This volume, p. 269.
§ This volume, p. 269.

G. 5. Scyra, *Dana.**—Carapax gibbosus, rostro mediocri, laminato, cornubus acutis, dente præorbitali acuto. Margo orbitalis superior paulo unifissus. Articulus antennarum ext. 1mus omnino angustus, 2dus depressus.

G. 6. Hyastenus, *White.*†—*Chorino* affinis. Rostrum prælongum, cornubus non depressis, ante poneque oculos directus. Margo orbitalis superior unifissus. Pedes 2di longiores.

9. PYRINÆ.—Carapax subpyriformis. Pedes 8 postici valde compressi.

G. 1. Pyria, *Dana.*—Carapax depressus, inermis, rostro lamellato, cornubus ovatis. Oculi perbreves, orbitâ spinis non armatâ.

b. OCULI LONGITUDINALITER PORRECTI, CARAPACE ANTICE TRUNCATO.

10. OTHONINÆ.—Carapax antice late truncatus, rostro fere obsoleto. Oculi elongati, cylindrici.

G. Othonia, *Bell.*‡—Carapax parce oblongus, suborbicularis, rostro bifido. Antennæ internæ minutissimæ; externæ latæ, articulo 1mo lato, 2do valde depresso, inverso-subtriangulato.

B. Carapax paulo transversus.

81. SALACINÆ.—Carapax fere orbicularis. Pedes 8 postici crassi, longi, articulo penultimo infra recto. Rostrum fere obsoletum integrum.

G. Salacia, *Edwards* et *Lucas.*§—Carapax gibbosus. Fossa antennalis sub rostro partim excavata. Articulus maxillipedis externi 3tius medio apice emarginatus, hocque emarginatione articulum proximum gerens. *Inacho Grapso*que affinis.

2. DIGITI APICE OBTUSI, INSTAR COCHLEARIS EXCAVATI.

12. MITHRACINÆ.—Oculi mediocres. Carapax sive paulo oblongus, sive transversus.

G. 1. Mithrax, *Leach.*‖—Carapax sæpe orbiculato-ovatus, interdum transversus. Rostrum aut saliens aut fere obsoletum, bifidum. Articulus antennarum ext. 1mus apicem externum duabus spinis longis armatus.

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* This volume, p. 269.

† Ann. Mag. Nat. Hist, [2], xx, 61, and Crust. Voy. of Samarang, p. 11. The species is Seba's fig. 12, pl. 18 of the Thesaurus.

‡ Zool. Trans., ii, 55.

§ Crust. in D'Orbigny's S. Amer., 12, pl. 11.

‖ The characters given by White for his genus *Schizophrys* (Ann. Mag. N. H. [2], ii, 282, 283, and Voy. Samarang, Crust., p. 16) do not serve to exclude the species from Paramithrax, Maia or Mithrax. The peculiarity of the orbit described and of the 1st joint of the outer antennæ, as far as understood by the writer from the description, are the same as in the genera just mentioned.

The genus *Dione* of De Haan (Fauna Japon. Crust. p. 82.) differs from Mithrax only in not having the interior apex of the third joint of the outer maxillipeds project inward a little over the insertion of the fourth joint. It corresponds to "*Mithrax triangulaires*" of Edwards.

G. 2. MITHRACULUS, *White*.—Carapax transversus. Articulus antennarum ext. 1mus duabus spinis longis non armatus.

13. CYCLACINÆ.—Oculi longi.
G. CYCLAX, *Dana*.*—Carapax paulo oblongus, orbiculato-ellipticus, rostro sat brevi, bifido, acuto. Pedes 8 postici longi.

FAM. II. TYCHIDÆ.

OCULI RETRACTILES, SUB CARAPACE LATENTES, ORBITIS CARENTES.

1. CRIOCARCININÆ.—Rostrum valde deflexum. Carapax oblongus.
G. CRIOCARCINUS, *Guerin*.—Oculi prælongi, orbitæ margo superior processu longo lamellato apicem armato instructus.

2. TYCHINÆ.—Carapax oblongus, anticè latus, latitudine trans-orbitali grandi, rostro non deflexo, sat longo, furcato. Oculi apice paululum exserti.
G. TYCHE, *Bell*.*—Carapax depressus, anticè cornubus rostri spinisque duabus præorbitalibus totis parallelis et subæquis confectus, spinâ post-orbitali nullâ. Articulus antennarum ext. 1mus oblongus, inermis.

3. CAMPOSCINÆ.—Carapax oblongus, rostro fere obsoleto, emarginato. Pedes 8 postici longi. Oculi longè pedunculati et exserti.
G. CAMPOSCIA, *Latreille*.—Carapax subpyriformis, non armatus. Pedes 8 postici subcylindrici, 2di 3tiis breviores.†

FAM. III. EURYPODIDÆ.

OCULI RETRACTILES, NON SESE LATENTES.

1. *Antennæ externæ apertæ.*

1. EURYPODINÆ.—Carapax triangulato-ovatus, rostro longo, furcato. Pedes longi, 4 postici non bene prehensiles. Oculi longi et longe salientes. Spina post-orbitalis oblonga.
G. EURYPODIUS, *Guerin*.—Pedes 8 postici longi, articulo penultimo valde compresso, ensiformi.
G. OREGONIA, *Dana*.‡—Pedes 8 postici sat longi, articulo penultimo subcylindrico.

2. *Antennæ externæ sub rostro celatæ.*

AMATHINÆ.—[An oculi retractiles, iis *Eurypodii* similes, eoque genus hac sede?] Carapax triangulato-ovatus, rostro furcato, latitudine trans-orbitali perangustâ. Pedes longi.
G. AMATHIA, *Roux*.—Carapax gibbosus, valde armatus, rostro prælongo, cornubus divaricatis. Pedes filiformes, prælongi. Oculi parvi. Articulus antennarum ext. 1mus perangustus. Epistoma fere quadratum.

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* This vol., p. 269. † Zool. Trans. ii, 57. ‡ This vol., p. 270.

Fam. IV. LEPTOPODIDÆ.

Oculi non retractiles, sese non latentes. Pedes prælongi.

A. Antennæ externæ apertæ.

1. ACHÆINÆ.—Carapax triangulato-ovatus, rostro perbrevi, bifido. Oculi longi, longèque salientes. Pedes 4 postici subprehensiles.
   G. 1. Achæus, *Leach.*—Carapax gibbosus. Pedes 8 postici filiformes, longi, tarso pedum 4 posticorum falciformi, articulis penultimis subcylindricis.

2. INACHOIDINÆ.—Carapax triangulato-ovatus, rostro elongato, simplice.
   G. Inachoides, *Edw.* et *Lucas.**—Carapax valde gibbosus, rostro longiusculo, acuto, spinâ postorbitali parvâ. Pedes 8 postici sat longi, gracillimi. Articulus antennarum ext. 1mus angustus.

B. Antennæ externæ celatæ.

3. LEPTOPODINÆ.—Carapax triangulato-ovatus, rostro elongato, simplice. Pedes longissimi.
   G. Leptopodia, *Leach.*—Oculi sat salientes. Pedes toti gracillimi.

4. STENORHYNCHINÆ.—Carapax triangulato-ovatus, rostro breve, bifido.
   G. Stenorhynchus, *Lamark.*—Oculi sat salientes. Pedes antici crassiusculi.

Fam. V. PERICERIDÆ.

Oculi non retractiles, sese non latentes. Pedes longitudine mediocres.

A. Antennæ externæ apertæ.

1. PARAMICIPPINÆ.—Rostrum valde deflexum. *Micippæ* aspectu similes.
   G. Paramicippa.—Rostrum latum, articulus antennarum ext. 2dus breviter cordiformis. Epistoma perbreve.

2. PERICERINÆ.—Rostrum profundè bifidum, non deflexum.
   G. 1. Pericera, *Latreille.*—Carapax sæpe triangulatus, interdum orbiculato-ovatus, paucis spinis sæpius armatus, rostro divaricatè furcato. Articulus antennarum ext. 1mus apice latus et spinâ armatus. Orbita tubulata, oculum strictè includens, margine superiore subtiliter unifisso.
   G. 2. Tiarinia, *Dana.*†—Carapax subpyriformis, tuberculis plerumque pustuliformibus sæpeque aggregatis ornatus, rostri cornubus gracilibus contiguis. Articulus antennarum ext. 1mus apicem latus et inermis, angulo externo interdum saliente tantum.

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* Crust. in D'Orbigny's S. Amer., 4, pl. 4.

† This volume, p. 271.

G. 3. PERINIA, *Dana.**—Carapax orbiculato-ovatus, tuberculis paucis non acutis ornatus, rostri cornubus brevibus, discretis. Articulus antennarum ext. 1mus oblongus, apicem non latior, angulo externo valde producto. Orbita anticè aperta, margine superiore non unifisso.

G. 4. HALIMUS, *Latreille.*—Carapax triangulato-ovatus, cornubus rostri grandibus, divaricatis. Articulus antennarum ext. 1mus angustus. Articulus pedum 8 posticorum 5tus valde compressus, processu infra non armatus.

G. 5. PUGETTIA, *Dana.*†—Carapax triangulato-ovatus. Rostro antennisque ext. *Halimo* affinis. Articulus pedum 8 posticorum 5tus cylindricus.

3. MENÆTHIINÆ.—Rostrum integrum aut subintegrum.

G. 1. MENÆTHIUS, *Edwards.*—Carapax triangulato-ovatus, depressus, regione antero-laterali plicis tribus plus minusve ornatâ. Pedes 8 postici cylindrici. ‡

G. 2. ACANTHONYX, *Latr.*—Carapax depressus, non tuberculatus, sive subtriangulatus sive subquadratus (dente post-orbitali dilatato), regionibus non conspicuis, dente præorbitali parvulo, rostro crasso, apice emarginato. Pedes 8 postici mediocres, articulo penultimo compresso, infra dilatato et sæpe dentigero.

G. 3. ANTILIBINIA, *M'Leay.*§—Carapax valde convexus, regionibus non conspicuis, latitudine transorbitali minore (lat. max. 3plo latiore), rostro crasso, apice emarginato. Articulus pedum 8 posticorum penultimus infra non dilatatus nec dentigerus.

G. 4. PELTINIA, *Dana.*‖—Carapax depressus vix tuberculatus, dente præorbitali breviter instructus, latitudine transorbitali majore (lat. max. 2plo latiore), rostro lato, profundè bifido, sat brevi. Articulus pedum 8 posticorum penultimus infra non dilatatus nec dentigerus.

B. Antennæ externæ sub rostro celatæ.

1. Oculi prælongi.

4. STENOCIONOPINÆ.—Rostrum longum, furcatum, cornubus styliformibus, divaricatis.

G. STENOCIONOPS, *Latreille.*—Carapax subpyriformis, gibbosus, spinâ præorbitali longissimâ. Articulus antennarum ext. oblongus.

2. Oculi aut longitudine mediocres aut perbreves.

5. EPIALTINÆ.—Rostrum oblongum, crassum, sive integrum sive emarginatum. Antennæ ext. apicem rostri sæpius non attingentes. Pedes 8 postici subcylindrici.

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* This volume, p. 271.

† Ibid, p. 268.

‡ The genus *Viphus* of Eydoux and Souleyet, as figured in the plates of the Voyage of the Bonite, has the beak, præorbital spine or tooth, outer antennæ, and general form of Menæthius. But the eyes may be longer pedunculate, and as there is no description, it is not apparent whether they are retractile or not. The species is called *Viphus margaritiferus.* The beak is pointed, and the 3d basal joint of the outer antennæ reaches to apex of beak.

§ Smith's Illust. S. Af. Zool.

‖ This volume, p. 272.

G. 1. Epialtus, *Edw.*—Carapax inermis, vix tuberculatus, regionibus non conspicuis. Octo pedes postici nudi aut subnudi, articulo penultimo infra sæpe subdentigero.

G. 2. Huenia, *De Haan.**—Carapax 2–4 tuberculis acutiusculis sæpius armatus, interdum inermis, regionibus inconspicuis, rostro simplice, angulo carapacis postero-laterali prominente. Articulus pedum 8 posticorum penultimus plerumque infra dilatatus, dentigerus.

G. 3. Xenocarcinus, *White.*†—Carapax tuberculis subacutis sparsim armatus, rostro simplice, truncato, margine postero-laterali non angulator, otundato.

G. 4. Leucippa, *Edw.*—Carapax subtriangulatus fere inermis, regionibus non conspicuis, spinâ præorbitali nullâ. Pedes supra carinati, articulo penultimo infra non producto. Dens post-orbitalis prope oculum insitus, oculum vero non celante.

Genus Zebrida, *White*,‡ incertæ sedis; antennis externis obitâque *Eumedono* similis, eoque Parthenopineis congruit.—Carapax depressus, non armatus antice latior, dente post-orbitali portentosè expanso, rostro latissimo, lamellato, profundè furcato. Oculi paululum salientes. Pedes compressi, angulati. Articulus antennarum externarum 1-mus *hiatum orbitæ occupans*, antice non productus.

2. *The Apteryx of New Zealand.*—With the skin of the *Notornis Mantelli* described in the January number of this Journal, xi, 102, Mr. Walter Mantell sent the skins of three birds of the genus Apteryx; one of them is the small and rare species figured and described in the Zoological Transactions of London, by Mr. Gould, as *A. Owenii*. The other skins were supposed to be of the common species, generally known as the *Apteryx australis;* of which some thirty or forty specimens have been sent to Europe, and are distributed in the public and private zoological collections of England and the continent. One of Mr. Mantell's specimens was remarkable for its large size, and short and strong legs; but though seen by many eminent ornithologists in London, it was regarded only as a very large and fine example of the common species, till Mr. Bartlett, the eminent taxidermist, in whose hands it was placed by Dr. Mantell to stuff and mount, compared it with the various specimens in the British museum, and in the collections of the Zoological Society, and ascertained that it was specifically distinct from that usually named the *Apteryx australis*. Mr. Bartlett therefore drew up a description of this bird to lay before the Zoological Society: but fortunately first applied to the Earl of Derby for the loan of the original specimen figured and described by Dr. Shaw, in 1812, and which at the death of that naturalist passed into Lord Derby's possession. Upon receiving this bird, Mr. Bartlett found that it was identical with the supposed new species sent home by Mr. Walter Mantell; the latter therefore is the true Apteryx australis of Dr. Shaw, and only the second example known in Eng-

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* Crust. Faun. Japon. 73.

† Jukes's Voy. H. M. S. Fly; Ann. Mag. N. H. [2], i, 331; Crust. Voy. Erebus and Terror, pl. 2, fig. 1.

‡ Crust. Voy. of Samarang, p. 23.

land : the common species having been hitherto confounded with it, from no careful comparisons having been instituted with the original type. As the ordinary and smaller species is thus deprived of a specific name, Mr. Bartlett has given it that of *Mantelli* to commemorate the scientific researches of the young naturalist whose labors have so much extended our knowledge of the recent and extinct faunas of New Zealand. There are now however three species of this extraordinary "wingless" bird, viz., *Ap. australis*, *Ap. Owenii*, and *Ap. Mantelli*. It is probable that a fourth and much larger species still exists in the Middle Island. Mr. Bartlett's memoir on this subject will appear in the Proceedings of the Zoological Society of London. It is very probable that in some of the ornithological collections in this country—for example in that of the Academy of Natural History of Philadelphia—a specimen of the true *Ap. australis* may occur; having been mistaken for a large variety of the more common species, now the *A. Mantelli;* at all events we would recommend our scientific friends to examine the various examples of Apteryx in their collections with a view to this question. We may add that both Dr. Shaw's and Mr. Walter Mantell's specimens were from the Middle Island : the more abundant species is from the North Island.

3. *Ibis guarauna in New England;* by Dr. CABOT, (Proc. Bost. Soc. Nat. Hist., Nov., 1850, p. 313.)—*Ibis guarauna* has been confounded with *I. falcinellus* by many naturalists, among others even by Nuttal, Buonaparte, and Audubon. Lately our newspapers have contained several notices of some specimens of the Glossy Ibis which have been procured in different parts of this state, with various theories to account for their appearance in this part of the world, (such as, that they had passed round by Behring's Straits, &c.) all of which are absurd for several reasons : 1st. The bird is not the same as that found in the old world; it is larger. 2nd. The *I. falcinellus* is rare in the north of Europe as *I. guarauna* is here. 3d. Since the bird feeds on living animals and plants, it could not subsist on its voyage through the arctic regions at the early season at which it must have passed; it could much more easily have come straight across the ocean. 4th. We have a much more easy way of accounting for their appearance, namely, the *I. guarauna* (the bird which has been mistaken for *I. falcinellus*) is found in immense flocks in Mexico and in considerable numbers in Texas and Florida, where it breeds; so that, to account for their appearance here, we have only to suppose that a few wandered a couple of days' journey farther north than usual, as we know to have been the case occasionally with other southern birds, as the Martinico and Florida Gallinules, White Egret, Pelican, &c. During the present month, [June,] four specimens of the *I. guarauna* have been procured in the New England states, three of them in Massachusetts, of which one was shot by Mr. F. Brown on the Fresh Pond marshes, and by him presented to the Harvard Natural History Society, who with great liberality presented it to us. The other two are in the possession of Mr. Jenks, of Middleboro', where they were shot. One was procured in Middletown, Ct., and is in the possession of Dr. J. Barrett of that place. Nuttal says, that they are occasionally exposed for sale in Boston markets; probably at the time when he made this observation there

had been a flight of them into this state, similar to what has occurred this year; for during the past eighteen years (with the exception of three) Dr. Cabot had kept a very close watch upon our markets, with the express purpose of procuring birds for his own and the Society's collection, and in that time he had never seen a single specimen of this bird.

IV. Miscellaneous Intelligence.

1. *Abstract of Meteorological Observations made at Burlington, Vt., in* 1850; by Z. Thompson.—*Note.* The location is one mile from the shore of Lake Champlain, and 256 feet above the lake (346 above the sea) in lat. 44° 29′, and long. 73° 11′.

1850.	THERMOMETER.				BAROMETER.			
Months.	Mean.	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.
	°	°	°	°	Inches.	Inches.	Inches.	Inches.
January, . .	23·74	46	−1	47	29·86	30·37	29·10	1·27
February, . .	24·32	54	−18	72	29·65	30·49	28 81	1·68
March, . .	30·47	49	0	49	29·68	30·26	29·17	1·09
April, . . .	41·02	76	17	59	29·65	30·09	28·98	1·11
May, . . .	51·64	75	33	42	29·60	30·00	29·00	1·00
June, . . .	67·13	93	46	47	29·69	29·99	29·41	0·58
July, . . .	70·04	89	47	42	29·69	29·98	29·33	0·65
August, . .	66·03	90	43	47	29·69	2.) 97	29·28	0·69
September, .	59·69	82	40	42	29·69	29 96	29·30	0 66
October, . .	48·25	70	28	42	29·62	29·95	29·09	0·86
November, .	40·38	62	26	36	29·72	30·05	28·99	1·06
December, .	18·65	46	−10	56	29·75	30·28	28·80	1·48
An. M.	45·14			111	29·69			1·69

1850.	WINDS.								WEATHER.		SNOW.	WATER.
Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Fair.	Cloudy.	Inches.	Inches.
January,	8	1	2	3	10	2	1	4	13	18	16	1·57
February,	9	1	1	2	11	0	2	2	15	13	18	1·79
March,	13	1	0	1	8	1	5	2	20	11	12	1·11
April,	6	1	1	2	11	1	4	4	22	8	8	2 41
May,	6	2	2	4	10	2	3	2	18	13	0	5·04
June,	7	2	0	2	14	1	2	2	23	7	0	3·18
July,	9	0	0	2	16	1	1	2	23	8	0	5·08
August,	14	0	0	2	13	0	1	1	27	4	0	0·89
September	8	0	2	1	15	0	1	3	22	8	0	3·25
October,	7	0	0	1	15	1	1	6	17	14	5	8·11
November,	7	1	1	2	12	1	3	3	16	14	1	1·77
December,	11	2	2	1	11	0	1	3	14	17	48	3·31
	105	11	11	23	146	10	25	34	230	135	108	37·51

The results in the above tables are deduced from three daily observations made at sun-rise, 12 M. and 9 P. M. The warmest day in the year was the 19th of June, the mean heat of which was 82°; the coldest day was the 5th of Feb., the mean of which was —6°. The mean temperature of the year was 0°·23 warmer than the average of the twelve preceding years. The range of the thermometer was 6° less, and the range of the barometer 0·13 in. greater than in 1849.

The column of water includes the rain and melted snow; and the amount in 1850, was 5·3 inches greater than the average annual fall in the preceding twelve years, and was more than fell in any one of those years, excepting 1847, in which the fall was 38·55 inches.

The broad part of the lake opposite to Burlington, was not frozen over during the year, an occurrence which has been witnessed only three times in the last thirty-four years. During the year there were eighty-four days of tolerable sleighing in Burlington and vicinity.

The water of the lake was highest May 29, being then one foot ten inches below extreme high-water mark, and lowest Jan. 1, being five feet ten inches below high-water,—change of level of the lake in the year, four feet. The extreme change of level is about eight feet. A severe rain storm occurred on the 18th, 19th, and 20th of July—fall of water 3·62 inches—crops along the streams overflowed and nearly ruined—railroads and other roads much injured.

October 26 and 27, another severe rain storm terminating with a fall of five inches of snow—depth of water from rain and snow, 3·78 inches.

December 23, remarkable snow storm with high winds—twenty inches of snow, much drifted—roads nearly impassible for several days.

Barn swallows appeared May 2; currants blossomed May 13; plums and cherries, 20; Siberian crab-apple, June 2; common apple, June 4.

2. *Magnetic Observatory at Toronto.*—We are indebted to Prof. Henry for a copy of the following letter from the Hon. Abbot Lawrence, informing him of the decision of the Lords of the Treasury with regard to the continued support of the Toronto Observatory; a subject which deeply interested the members of the American Association at its last meeting at New Haven.—Eds.

"*My Dear Sir*,—I have the pleasure to inform you that I received a communication last evening from the Viscount Palmerston upon the subject of your letter addressed to me in October last, a copy of which I have transmitted to the Secretary of State, Mr. Webster—I also received a letter from the Secretary of the American Scientific Association which assembled last year at New Haven. You will oblige me by communicating the result of my application to this government to such persons as you may deem proper. I have known for several weeks that the Lords of the Treasury would continue the appropriation for the Observatory at Toronto. I had not however received the information in an official form till now.

I am, dear sir, most faithfully, your obedient servant,
Joseph Henry, Esq., Washington." Abbott Lawrence.

3. *African Geography*; (Proc. Geog. Soc., London, in Athenæum, No. 1217.—Two communications on African geography preceded the papers of the evening. In the first, mention was made of the successful ascent of the cataract of the White Nile which had stopped the further progress of D'Arnaud. The expedition, consisting of the missionaries, Dr. Knoblicher (Vicar), Don Angelo Binco, and Don Emanuel Pedemonte, started with seven vessels from Khartum, on Nov. 13, 1849. On the 14th Jan., 1850, the great cataract was for the first time prosperously ascended, under the guidance of their bold pilot Suleiman Abu Zaid, favored by a strong north wind. Immediately above the cataract, the navigation of the river was rendered extremely difficult by sand-banks, and higher up by rocks. At the village of Tokiman, the surprise of the natives at the sight of the vessels and of white men was amusing. The party arrived at Logwek on the 16th of January, where Dr. Knoblicher ascended a lofty granite hill, from the top of

which the White Nile could be seen stretching away to the southwest, and in the distant horizon the summits of a range of lofty mountains were distinctly traced. At the 4° of lat., the Nile was 200 yards broad, and from two to three deep.—In the second African paper, the Rev. D. Livingston communicated, through the London Missionary Society, an account of another large lake, 150 to 200 miles to the northwards of Lake Ngami, the discovery of which was announced last year, and for which Mr. Livingston received the second prize of the Society. The new lake contains large islands, on one of which Sebetoane, the well-known chief, resides. The two lakes are connected by a rapid stream, the Teoge. The inhabitants around this lake are said to be in communication with the Portugese settlements on the coast. Mr. Livingston intended proceeding again shortly to the north on a visit to the chief.

4. *The sources of the Nile;* (Athenæum, No. 1217.)—The *Times* of Saturday last contains a letter from a correspondent at Vienna, dated February 9th, from which the following is an extract :—

"As everything connected with the sources of the Nile is likely to prove interesting to the British public, I must not omit to inform you that I have to-day had an interview with Dr. Knoblicher, the Pope's Vicar-General in Central Africa, who, after having passed some years among the Maronites, in the Lebanon, founded an establishment at Khartum, at which city the main river separates into the White and Blue Nile. Along the former, the Rev. Doctor travelled to within 4 deg. 9 min. of the equator. He twice ascended a mountain called Logwek, in the latitude above mentioned, and saw the Nile trending away in a southwesterly direction, until it vanished between two mountains. The last natives he met with, the Bary negroes, informed him that beyond those mountains the river came straight from the south. The Nile was in 4 deg. 45 min. north latitude, 200 French mètres broad (about 625 English feet) and from three to five mètres deep. Dr. Knoblicher, a native of Laibach, in Carniola, and as a linguist a worthy disciple of Mezzofanti, is of opinion that the source of the Nile is to the south of the equator; and he is confirmed in this idea by the fact that the river was rising on the 16th of January, which he considers as a consequence of the rainy season having set in, in districts much farther south. Dr. Knoblicher left Khartum on the 13th of November, 1849, reached the country of the Bary negroes, whom he estimated at about 2,000,000, on the 16th of January, 1850, and arrived at Khartum again the 7th of March. The enterprising and intelligent traveller's journal is most interesting; with true German patience he has noted, frequently six times in an hour, all the changes in the direction of the river, the velocity of the current, the direction of the wind, the peculiarities of the vegetation, the appearance of the heavenly bodies, &c.; in short, everything which can possibly be of interest to scientific men. It was most interesting to see his reverence filling up the map of Africa published by the Society for the Diffusion of Knowledge agreeably to the surveys entered in his diary. The Austrian traveller will be with the Bary negroes again in November next, as he is determined to continue his researches. It was with a painful feeling that I learnt in the course of conversation that Dr. Knoblicher had not been able to go to

the expense of a chronometer before he started on his journey ; he had a sextant, thermometer, barometer, &c., and 'Griffin's Practical Navigation,' but the great essential was and still is wanting."

The spot to which Dr. Knoblicher thus succeeded in penetrating is several miles higher up the stream than the extreme point reached, in 1841, by the second Turco-Egyptian Expedition sent by the late Mohammed Ali Pasha to discover the source of the Nile,—in which Expedition M. d'Arnaud and M. Werne took part ; and the explicit information now furnished by him respecting the upper course of the river sets at rest the question as to whether it came from the east or from the south, arising out of the conflicting statements of those two travellers.

I may add, that the course of the river above 4° N. lat., as described by Dr. Knoblicher, corresponds very closely with that which is marked in the map of 'The Upper Nile according to Dr. Beke's Hypothesis,' published in the *Edingburgh New Philosophical Journal* for October, 1848, vol. xlv, No. 90, in illustration of a paper, 'On the Sources of the Nile in the Mountains of the Moon,' contained in the same number of that journal. I am, &c., CHARLES BEKE.

February 18.

5. *Survey of the Louisiade Archipelago and the Southeast Coast of New Guinea ;* by the late Capt. O. STANLEY, R.N., with Notes on the Natural History of the same, by Mr. MACGILLIVRAY, the Naturalist to the Expedition.—(Proc. of Geog. Soc., Athenæum, No. 1214.)—After a passing tribute of respect to the memory of the lamented Mr. Kennedy, murdered, as our readers know, by the natives during his exploration of the Cape York Peninsula—Capt. Stanley (destined so soon to follow him) mentioned the rescue of a Scotch female, the only survivor out of a small vessel wrecked upon the islands, and who had lived four years among their wretched inhabitants. As she had acquired a perfect knowledge of their language, Mr. MacGillivray availed himself of the opportunity of collecting a vocabulary, which has been placed in the hands of Dr. Latham for publication. The most important feature of Guinea seen was a high range of mountains, extending from the Cul de Sac de l'Orangerie to Redscar Point, a distance of nearly 300 miles—some of the peaks of which were more than 10,000 feet above the level of the sea, and one was as much as 12,800 feet. The land both in North Guinea and in the Louisiade is remarkably fertile and very thickly inhabited. The natives are described as treacherous ; and on one occasion, when they attacked the boats of the surveying ships and wounded two of the crew, it became necessary to exercise a little judicious ball practice over their heads. The inhabitants appear to be an intermediate race between the Malays and the South Sea Islanders. The islands seem to be of volcanic origin, and are surrounded by a regular barrier reef, which, however, towards the west ceased to be continuous, and permitted an easy passage to the open sea. Although, however, the barrier-reef ceased on leaving the Louisiade, Capt. Stanley found on approaching New Guinea, in order to obtain an astronomical position from whence to carry out the survey, that a ridge of shoal water, *not at all visible from the mast-head*, stretched out about six miles from the land, rendering the navigation here extremely dangerous. After passing this ridge the soundings became more regular. Dense masses of

clouds, hanging over the highlands of New Guinea, prevented their seeing so much of this splendid country as they could have desired, but that portion which was seen is described as surpassing any natural scenery Capt. Stanley had ever met with. The ground appeared to be well cultivated, and numerous small villages along the coast, well sheltered among the trees, gave additional charms to the view. The currents are described as strong and setting in various directions; but the great fact was established by the survey, "that there is a clear channel along the southward of the Louisiade and New Guinea, which, if adopted, will prove by far the safest route for vessels bound to India from New Zealand, and also for those returning during the westerly monsoon in the Arafura Sea." Mr. MacGillivray gave an elaborate description of the collections in natural history made during the survey (shortly to be published); and the movements of the Expedition were further explained by several of the officers on the maps just finished and sent by Admiral Beaufort for that purpose.

6. *On Peat and its Products*; by Prof. BRANDE.—(Proc. Roy. Soc., Jan. 31, Athenæum, No. 1217.)—A peat bog was described as a superficial stratum of vegetable matter, which at different depths is undergoing, or has undergone, various stages of change and decomposition. Its superficial appearance is that of a mass of half decayed mosses, rushes, heath, and grass; the roots having successively died away, though the plants continued to vegetate. The mass is ligneous and imbued with humus and humic acid, among other products of slow decay; and the abundance of moisture pervading the bog affects the character at once of the peat and of the district. The upper layers of the bog are usually loose and fibrous and of a pale brown color. Beneath the surface the density is found to increase, sometimes to a great extent. At last, the distinct characters of the vegetable cease to be discernible, and the mass appears nearly homogeneous and of a dark brown or blackish color. Trunks of trees and some curious geological phenomena occasionally present themselves. A peat district may be regarded therefore as the consolidated produce of enormous forests and fields of vegetation, amounting in the aggregate to millions of acres. In Ireland alone one-tenth of the surface is covered by peat bog, which if removed would exhibit a soil fit for the operations of agriculture. Prof. Brande then invited attention to different samples of peat taken from the upper, middle, and lower portions of the bog. He particularly noticed the tallow peat of the banks of Lough Neagh, which, from the brilliant flame attending its combustion, is sometimes used as a source of light as well as of heat. Peat may be rendered valuable, either—1. From the charcoal which may be obtained from it; or—2. By the various products derivable from what is called its destructive distillation. When it is desired to convert peat into charcoal, the plan adopted by the Irish Amelioration Society is to carbonize blocks of peat, partially dried on trays of wickerwork, in moveable pyramidal furnaces. The charcoal so obtained varies in character with that of the peat which produces it; and when the peat is compressed previous to its carbonization, which may be well effected by means of a machine invented by Mr. Rogers, and which was explained by reference to a diagram, the resulting charcoal exceeds the density of common wood charcoal. In stove-drying, dense peat

loses about one-third, and the light and porous half of its weight: four tons of dried peat will give about one ton of charcoal. The efficacy of this charcoal in the manufacture of iron, in consequence of the small quantity of sulphur it contains, was mentioned; and its deodorizing and purifying qualities experimentally exhibited.—2. The products of the destructive distillation of peat were then described. The elements of peat are essentially those of wood and coal; viz., carbon, nitrogen, hydrogen, and oxygen. If therefore peat were distilled in close vessels, the products obtained, would, as might be expected, resemble the products of a similar operation on coal or wood. Hitherto, however, the expense of such a process in the case of peat has precluded its general adoption. Mr. Reece however has employed for this purpose a blast-furnace, which differs in principle from that in which iron is melted, by having an arrangement to collect the products of combustion; and he has thus succeeded in obtaining ammonia, acetic acid, pyroxylic spirit, tar, naphtha, oils and paraffine, together with large quantities of inflammable gases from the peat. In conclusion, Prof. Brande reviewed the various products of peat and their uses. They appear to be—1. Sulphate of ammonia. This substance is employed in preparation of carbonate and muriate of ammonia, of caustic ammonia, and in the manufacture of manures and fertilizing composts. 2. Acetate of lime, which is in constant demand as a source of acetic acid, and of various acetates largely consumed by the calico printers. 3. Pyroxylic spirit (or wood alcohol) used in vapor lamps, (two of which were exhibited and attention called to the brilliancy of the light afforded,) and in the preparation of varnishes. 4. Naphtha used for making varnishes, and for dissolving caoutchouc. 5. Heavy and more fixed oils, applicable for lubricating machinery, especially when blended with other unctious substances; or as a cheap lamp oil, and as a source of lampblack. 6. Pauraffine. This when fixed with fatty matter forms a material for candles, samples of which were shown consisting of a mixture of paraffine, sperm, and stearine.

7. *On Printing Ferns, Sea-weeds, &c.*, (Athen., No. 1208.)—In the *Athenæum* for December 14th, you have inserted an extract from a Sheffield paper, giving an account of my "Method of producing Plates for Printing Ferns, Sea-weeds," &c. (See p. 280 of this volume.) As that account is very imperfect, will you allow me a small space in your columns to explain my plan more clearly.

A piece of gutta-percha free from blemish, and the size of the plate required, is placed in boiling water;—when thoroughly softened, it is to be taken out and laid flat upon a smooth metal plate, and immediately dusted over with the finest bronze powder used for printing gold letters. The object of this is threefold:—to dry the surface,—to render the surface more smooth,—and to prevent adhesion. The plant is then to be neatly laid out upon the bronze surface, and covered with a polished metal plate, either of copper or of German silver. The whole is then to be subjected to an amount of pressure sufficient to imbed the upper plate in the gutta-percha. When the gutta-percha is cold, the metal plate may be removed, and the fern gently withdrawn from its bed. From the beautiful impression of the fern left in the

gutta-percha a cast in brass may be readily taken. As soon as the surface of the brass cast has been burnished,—of course carefully avoiding the impression,—it is ready for the copper-plate printer. If the printer skillfully mixes the ink to the tint of the fern, a print is obtained scarcely to be distinguished from the plant itself. The novelty of the process consists in causing the plant, so to speak, to engrave itself,—and also in the substitution of a cheap casting in brass for an expensive copper-plate engraving. Electrotype plates may be deposited on the bronzed gutta-percha, and a similar result obtained; but I have found the brass casting to answer equally well, and it has the advantage of being more durable, cheaper, and more expeditious. I send for your inspection, several prints of ferns produced by this process; and have, &c. FERGUSON BRANSON, M.D.

Sheffield, December 18.

8. *Note on Thapsus verbascum;* by H. A. RILEY, (from a letter to the editors, dated Montrose, Pa.)—It may be of interest to announce that a variety of Thapsus verbascum was observed by me the last season bearing white flowers. I found it about four miles east of Montrose, Pa., in the southeast part of Bridgewater and northeast of Brooklyn townships, on the road to the village of Harford. It was intermingled with the common yellow variety, constituting about one-fourth the plants of this species.

9. *Geological Survey of Pennsylvania.*—By a recent act of the Legislature of Pennsylvania, the Geological Survey of the State, so long interrupted for want of Legislative action, is again in the hands of Professor H. D. Rogers. Although not under appointment for some years past, Prof. Rogers has been making progress with his work, and we understand that his Report will soon be completed, after a re-survey of some portions of the state. The work will have a vast economical value, on account of the resources of the country in coal and iron, and a high scientific interest from its embracing a full developement of the carboniferous beds, besides other portions of the geological series. The Report will be fully illustrated by wood-cuts, maps and sections, besides numerous plates of fossils.

10. *Observatory of Altona.*—The place in the Observatory of Altona made vacant by the death of Schumacher, has been filled by the appointment of Dr. Petersen.

11. *Cabinet of Minerals for Sale.*—A valuable collection of minerals foreign and domestic, the property of a deceased physician, containing two thousand specimens. Said collection will be disposed of for money or education. Please address M. Leach, No. 6 Harrison street, south Brooklyn.

12. *American Association for the Advancement of Science.*—The annual meeting of the Association will be held in Albany, in August, commencing with the 3rd Monday of the month. The officers for the year 1851–'52 are as follows:

Prof. L. AGASSIZ, *President.*
" S. F. BAIRD, *Permanent Secretary.*
" W. B. ROGERS, *General Secretary.*
Dr. ALFRED L. ELWYN, Philadelphia, *Treasurer.*

A *semi-annual* meeting will be held in Cincinnati, commencing with the 1st Monday in May, at which time Prof. A. D. BACHE, the president of the last annual meeting (1850) presides.

The following is a list of the Local Committee for the meeting at Cincinnati :

Local Committee.

Hon. JACOB BURNET, *Chairman.*
Prof. O. M. MITCHEL,
CHARLES STETSON,
Hon. TIMOTHY WALKER,
Prof. HORATIO N. ROBINSON,
JOHN P. FOOTE, Esq.
Dr. J. A. WARDER,
Hon. NATHAN GUILFORD,
ROBERT BUCHANAN, Esq.
Rev. Dr. NATHAN L. RICE,
E. D. MANSFIELD, Esq.
Rt. Rev. JOHN B. PURCELL,
Dr. JOSEPH RAY,
Prof. BENJAMIN SILLIMAN, Jr.

Local Secretary.

DR. THOMAS RAINEY.

We cite the following from the circular recently issued by the Local Secretary at Cincinnati :

The meeting of the Association will open at 3 o'clock, P.M., on Monday.

The Secretary and a member of the Local Committee will be in attendance at the Burnet House, from Saturday until Monday afternoon, to direct members to the quarters secured for them ; the Local Committee having provided for the gratuitous entertainment of all members attending. It is desirable that the members, as they arrive in the city, should report themselves at the place above noticed.

A book of registration will be opened at the principal place of meeting.

Places of Meeting.—All *General Meetings* will be held in College Hall, on Walnut street ; *Section Meetings* will be held in adjacent rooms in the College Building.

Travelling Facilities.—The Secretary has been enabled to secure the privilege of transit of all members of the Association, who may pass over Lake Erie, or over the railroads of Ohio, at half the usual rates. Similar courtesies will doubtless be accorded by other lines of travel ; all of which will be duly published in the public journals some weeks previous to the meeting.

13. *Munificent Donation to Dartmouth College.*—A legacy of $50,000 has been left to Dartmouth College for founding a School of Arts, by Mr. Abiel Chandler of Boston. Mr. Chandler was a native of Concord, N. H., and a graduate of Harvard in 1806.

14. PROF. SILLIMAN and his son, Prof. Silliman, Jr., left the country on the 5th of March for England and the Continent, to return early in autumn. They reached Liverpool on the 16th.

OBITUARY.

C. W. B. GOLDSCHMIDT, (from a letter addressed by B. A. Gould, Jr., to one of the editors of this Journal.)—Death has been busy of late among the astronomers and mathematicians of Germany. The venerable and good Schumacher has passed away, and we have just been called upon to lament the loss which science has sustained in the decease of the

illustrious Jacobi at Berlin. The last mail has now brought intelligence of the death of Prof. Goldschmidt, of the Göttingen Observatory. You will doubtless be glad to give place in your Journal for a line of tribute to his memory, from one who knew and loved him well.

C. W. B. Goldschmidt was Extraordinary Professor of Astronomy in the University of Göttingen, and assistant to Gauss at the Observatory in that place; filling in both respects the position previously occupied by Prof. Harding, the author of the Celestial charts, and the discoverer of the planet *Juno*.

He was nurtured, like Jacobi, in the Hebrew faith, but his character was eminently conspicuous for the Christian virtue—love to God and man. Though perhaps not a great astronomer, he was an enthusiastic and a laborious one; and in his peculiar position, rendered unquestionably more essential and lasting services to astronomy, than many a man whose name will occupy a more conspicuous place in the annals of science. If the earnest devotion of a life to his favorite studies, and the sincerest efforts uprightly and conscientiously to fulfill the duties assigned him in the great march of scientific progress, can give a claim to the gratitude and remembrance of mankind, Goldschmidt's name will be long honored by those who never knew him. It will not easily be forgotten by those whose privilege and joy it was to call him their friend.

Among the scientific labors of Prof. Goldschmidt, I may mention his labors in connection with Gauss and Weber's *Resultate des Magnetischen Vereins*, and especially in preparing the Atlas of Terrestrial Magnetism, which accompanies that work; his discovery of the periodicity of the comet generally known as "Faye's;" his investigation of the minimum surfaces of rotation of curves about a fixed axis; and numerous computations of planetary and cometary orbits.

His death was like his life—quiet and peaceful. He had long suffered from the consequences of an enlargement of the heart; and on the morning of Feb. 15th, he was found in his bed, sleeping the sleep that knows no waking.

William Sturgeon.—Mr. Sturgeon, the eminent electrician, died on the 8th of December last. His researches have given his name a prominent place in the history of Science in England. Born of humble parents at Whittington, near Lancaster, in 1783, he was apprenticed early in life to a shoemaker. Subsequently he entered the Westmoreland militia, and after two years' service volunteered into the royal artillery, in which corps he served about twenty years. During his connection with the artillery, his attention was awakened by a terrific thunder-storm to thoughts on the mysterious power that was exhibited before him; and he resolved to study its nature. Books about him were few, and his early education deficient; but with the energy of genius, he took hold of the science from its foundation, acquired a good knowledge of mathematics, made much proficiency in Greek, Latin, French, German and Italian, that he might not be excluded from any of the sources of knowledge, and thus prepared, entered on the study of Natural Philosophy and especially the departments of electricity and magnetism. Such progress amid the constant and wearying routine and dissipating tendencies of military life, exhibits the high order of his

mind. His contributions to science, the fruits of this preparation and of his subsequent investigations, were exceedingly numerous. The following letter from Mr. J. P. Joule of Manchester, briefly announces some of the prominent results, and with slight exceptions correctly so.

"I have sifted Mr. Sturgeon's claims to the utmost. I have examined all the periodicals likely to throw light upon the history of electromagnetism, and find that Mr. Sturgeon is, without doubt, the originator of the electro-magnet, as well as the author of the improved electro-magnetic machine. The electro-magnet described by Mr. Sturgeon, in the Transactions of the Society of Arts for 1825, is the first piece of apparatus to which the name could with propriety be applied. Arago, and Ampere, and Davy had already, it is true, magnetized steel needles by passing currents of electricity along spirals surrounding them, but it does not appear that they observed the phenomena with iron needles, nor that they had any knowledge of the suddenness with which the polarity of soft wrought iron might be reversed by a change in the direction of the current. It appears, therefore, quite clear that to Mr. Sturgeon belongs the merit of producing the first electro-magnet constructed of soft iron, as well as that of ascertaining its peculiar and most remarkable properties. *Hence it was that M. Jacobi of St. Petersburgh, claimed for Mr. Sturgeon, in conjunction with Prof. Œrsted, the discovery of the electro-magnetic engine.* Mr. Sturgeon's claims with regard to the magneto-electrical machine appears to me to be equally well established. He was the first who devised and executed an apparatus for throwing the opposing currents into one direction, thus accomplishing for this machine exactly what Watt accomplished for the steam engine. Besides this, he is beyond dispute, the author of the system of solid brass disks and insulators, going by the name of "commutator" on the continent, and "unitrep" in America; an apparatus now universally employed in every magneto-electrical machine. Mr. Sturgeon was without doubt, the constructor of the first rotary electro-magnetic engine.*

"The use of amalgamated zinc plates in the voltaic battery was originated by Mr. Sturgeon. It is an improvement of such value that it has been universally adopted ever since, although all other arrangements of equal date have been superseded.

"Mr. Sturgeon's discoveries in the thermo-electricity and magnetism of homogeneous bodies are very important, and have placed his name higher than that of any other philosopher who, after Seebeck, has cultivated thermo-electricity.

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* It appears that Mr. Sturgeon made the first rotary electro-magnetic engine; but this was after Prof. Henry had published an account of his reciprocating electro-magnetic engine, which is upon the same principle with Mr. Sturgeon's instrument, the motion being reciprocating instead of rotary. With regard to the improvement of uniting the opposing currents of magneto-electric machines into one common current, this was made by Prof. Page, before it was *published* by Mr. Sturgeon, but not till after Mr. Sturgeon's result had been obtained, as appears from his references. But as to the means by which this was affected in Prof. Page's machine, to which he gave the name of "*unitrep.*" (the means now universally in use,) we believe Prof. Page to have been the first in introducing and describing it. His paper was published in this Journal five months before the publication by Mr. Sturgeon of his method.

"The above is only a very imperfect abstract of a small part of Mr. Sturgeon's discoveries and improvements in magnetism, electricity, and the kindred sciences. Though not himself the author of extensive generalizations, he has been signally useful in preparing the way for them, and in carrying them out practically; and I know not of one individual who, under equal or even less disadvantages, has contributed so eminently to the advancement of these highly interesting and useful sciences. (Signed,) JAMES P. JOULE."

Soon after he left the army, Mr. Sturgeon was appointed Professor of Natural Philosophy in the Military Academy at Addiscombe, and subsequently had the superintendence of the Victoria Gallery of Science at Manchester. The discontinuance of this Institution deprived him of his means of subsistence, and he was for a while thrown for resources on a precarious income from voluntary lectures. Less than two years before his death he was placed by Lord John Russell on the civil list for a pension of £50 per annum. A biographical notice in the Manchester Examiner and Times, from which the facts here given are taken, observes, "The death of this distinguished philosopher has created a hiatus that will not soon be filled up; and his loss is greater to his friends, in that, to great scientific attainments, he united a cordiality, and warm friendliness of character, that endeared him to all who knew him well. He was, in all respects, a fine, frank, manly fellow—one of the great original-minded men, of which Lancashire has produced so many, and of whom she may well be proud."

Dr. LINCK.—This eminent botanist of the University of Berlin, died on the 1st of January last, in his 82nd year. Dr. Linck was director of the Royal Botanical Garden in Berlin.

V. BIBLIOGRAPHY.

1. *Report of the Secretary of the Treasury on the Coast Survey*, dated Treasury Department, Feb. 15, 1851.

Report of Prof. Alexander D. Bache, Superintendent of the Coast Survey, showing the progress of the work for the year ending October, 1850.

The first of these Reports, from the Hon. Secretary of the Treasury, contains the results of his enlightened consideration of the question whether the progress of the Coast Survey would be promoted by its transferal to the Navy Department. His conclusion is given in a decisive manner, in the opening paragraphs of the Report, in which he says that he has "come to the full conviction that to transfer the work to the Navy Department would be to destroy it, by disorganizing the present admirably devised system, which, for efficiency and economy, can scarcely be improved; and which, in its results, has never been surpassed.

"This organization combines all the efficiency which can be derived from the army, the navy and the science of the country, assigning to each its appropriate sphere of action.

"Under this organization, the most rigid control is exercised over the expenditures, and a greater amount of work produced in proportion to the cost, than in any other operation of the same kind ever undertaken.

"Under this organization three-eights of the coast of the Atlantic and Gulf of Mexico have been surveyed, and, at the present rate of progress, the remainder will be completed within twelve to fifteen years, while the survey of the Pacific coast is rapidly advancing."

These and other points are discussed in the Report and presented in a forcible light, and due honor is bestowed upon the present illustrious head of the Coast Survey, who is preëminently fitted for the situation he holds.

The Report of the Hon. Secretary of the Treasury will have a hearty response from all who regard the true welfare and honor of the country.

The Report by Prof. Bache contains much information of interest which we must pass by for the present.

2. *The Annual of Scientific Discovery, A Year-Book in Science and Art*, exhibiting the most important Discoveries and Improvements in Mechanics, Useful Arts, Natural Philosophy, Chemistry, Astronomy, Meteorology, Zoology, Botany, Mineralogy, Geology, Geography, Antiquities, together with a list of recent Scientific publications, a classified list of Patents, Obituaries of eminent scientific men, an Index of important Papers in Scientific Journals, Reports, etc.; edited by DAVID A. WELLS, A. M., of the Lawrence Scientific School, Cambridge, and GEORGE BLISS, Jr.—428 pages, 12mo. Boston, 1851. *Gould & Lincoln.*—This volume ranges over all departments of science, culling from the researches of the year past, the more important facts and discoveries, especially those which bear upon the progress of the age in the useful arts, though not to the rejection of subjects of more purely scientific character. The selections have been made with discrimination, and evidently with much labor and study. The volume commences with a condensed review of the principal events in the advancement of science through the year 1850, occupying 15 pages; about 100 pages are next devoted to Mechanics, and the Useful Arts, and there are few concerned in any of the Arts that will not find some facts of special importance to them. Natural Philosophy and Chemistry occupy the next 150 pages; Geology, Zoology and Botany about 120 pages, and Astronomy, Meteorology, Geography and Antiquities the following 25 pages. This work is one of the most important means of diffusing knowledge through the country which has been projected, and will be found full of instruction and interest to the general reader, as well as to those interested in science.

3. *Principles of Zoology*, touching the Structure, Developement, Distribution and Natural Arrangement of the Races of Animals, living and extinct, with numerous illustrations. Part I, Comparative Physiology, for the use of Schools and Colleges, by LOUIS AGASSIZ and A. A. GOULD. Revised edition, 250 pp. 12mo., Boston, 1851. Gould & Lincoln.—Prof. Agassiz's thorough knowledge of every branch of zoology, and his facility in explaining to the unlearned the profoundest principles of the science, as well as the ability of Dr. Gould, commend this text-book to all who would study the subject of which it treats. A hand familiar with the minutest details, and at the same time with the highest generalizations, is everywhere to be seen through its pages. The chapter on the geological succession of animals contains original views of deep importance to geological science as well as to zoology.

4. *Smithsonian Institution Publications.*—The Smithsonian Institution, under the wise policy which has been adopted, and the general superintendence of Prof. Henry, has already made good progress towards carrying out the will of the testator, in the diffusion of useful knowledge. The amount of money injudiciously expended in the building, has however limited much the means of the Institution. Still the increase of the library and the publication of memoirs are going forward.

The following is a list of its publications, from Prof. Baird :—

I. *In Quarto.*—(1.) Ancient Monuments of the Mississippi Valley, forming Vol. I, of the Smithsonian Contributions to Knowledge.

(2.) Researches relative to Neptune, by SEARS C. WALKER.
(3.) Ephemeris of Neptune for 1848, " "
(4.) " " 1849, " "
(5.) " " 1850, " "
(6.) " " 1851, " "
(7.) Occultations for 1848. Computed by JOHN DOWNES.
(8.) " 1849. " "
(9.) " 1850. " "
(10.) " 1851. " "

(11.) On the Vocal Sounds of Laura Bridgeman, by Dr. FRANCIS LIEBER.

(12.) On the Physical Geography of the Mississippi Valley, by CHARLES ELLET, JR.

(13.) On Mosasaurus and the allied Genera, by Dr. R. W. GIBBES.

(14.) Aboriginal Monuments of the State of New York, by E. G. SQUIER.

Microscopical Examination of Soundings made by the U. S. Coast Survey, by Prof. J. W. BAILEY.

Microscopical Observations made in the Southern States, by Prof. J. W. BAILEY.

(15.) On the Explosiveness of Nitre, by Dr. HARE.

The preceding, excepting 1, 3, 7, 8, 9, constitute the second volume of Smithsonian Contributions.

(16.) Hints on Public Architecture, by R. D. OWEN, Esq. This was published by the Building Committee, but is not one of the series of Contributions.

II. *In Octavo.*—Annual Reports for 1846, 1847, 1848, 1849, (1850 in press.) Report on the Discovery of Neptune, by Dr. B. A. GOULD, JR.

Several 4to. Memoirs are in hand and will be put to press very shortly. Also, 8vo. Reports on the progress of several branches of science.

5. *An Elementary Treatise on Statics;* by GASPARD MONGE, with a biographical notice of the Author. Translated from the French by WOODS BAKER, A.M., of the United States Coast Survey. 216 pp. 12mo. Philadelphia, 1851. E. C. and J. Biddle.—This treatise contains a concise and perspicuous exposition of the principles of Theoretical Mechanics, well adapted for instruction in the higher institutions by its clear and rigorous style of demonstration, and fitted for promoting real progress in the mechanical arts, by its thorough exhibition of the great fundamental truths upon which they depend.

6. *Rainey's Improved Abacus:* An explanatory treatise on the Theory and Practice of Arithmetic and Mensuration; by THOMAS RAINEY. 313 pp. 16mo. Cincinnati, 1850, E. D. Truman.—This is a work of practical value in all kinds of calculations in mercantile and every day life. Thirty pages are devoted to figures of coins.

7. *Lichenes Americæ Septentrionalis Exsiccati. Fascic. I. and II.;* curante EDVARDO TUCKERMAN, A.M., Cambridge, Mass.—This volume is in fact a herbarium of Lichens in small 4to, labelled throughout, and therefore a most desirable work to the student of Cryptogamous plants, and to all general libraries. The department has long been the special study of Mr. Tuckerman, and the names assigned by him to the specimens are therefore full authority. The work is better than a book of engravings to the student, as it contains the objects themselves, and it has a standard value, exhibiting the characters and names of well established species for future comparisons in the farther prosecution of the science. The volume contains fifty species and varieties. Mr. Tuckerman's "Synopsis of the Lichens of New England" was noticed in the 5th volume (1848) of this Journal.

8. *The Old Red Sandstone or New Walks in an Old Field;* by HUGH MILLER, author of "Footprints of the Creator," &c. From the 4th London edition; 288 pp. 12mo, illustrated by numerous engravings. Boston: 1851. Gould & Lincoln.—Science has never been rendered more entertaining than in the works of Hugh Miller: and it is not an extraneous entertainment, but that proceeding from the exalted character and interest of the subject itself, through the workings of a mind that appreciates nature in her highest moral and physical aspects. With the author, stones seem to be as full of poetry as his own cultivated mind, and both appear as the eloquent expositors of the thoughts of God. "The Old Red Sandstone" and the "Footprints of the Creator," we would earnestly commend to all, scientific and unscientific. They contain the results of original research in science that may enlighten the most learned; at the same time, the simple glowing style of the author, his clear and vivid illustrations, and the ennobling views of truth which he presents, admirably fit these volumes for general instruction and improvement. The theologian may here learn rightly to apprehend God in his works; and the man of science, clearly to discern the God of revelation in nature.

REPORT OF THE BOARD OF TOPOGRAPHICAL ENGINEERS on the Inundations of the Lower Mississippi, by S. H. LONG, Lieut. Col., and A. A. HUMPHREYS, Capt., Members of the Board, dated Dec. 18. 1850, and Reported by the Secretary of War to the Senate, and ordered to be printed, Jan. 17, 1851.—Ex. Doc. No. 13, 2d Session 31st Congress.

J. W. ALEXANDER, Esq.: A Universal Dictionary of Weights and Measures, Ancient and Modern. Super-royal 8vo. *Baltimore*, 1851. Wm. Minifie & Co. Cloth, $1 50.—A work of great research and value.

F. OVERMAN: Practical Mineralogy. 230 pp. 12mo. *Philadelphia*, 1851. Lindsay & Blakiston.

ANDREW PRITCHARD: History of Infusoria, living and fossil.—In course of preparation a new and greatly enlarged edition. Price to subscribers 21*s.*

FREDERICK DIXON, Esq., F.G.S.: The geology and tertiary fossils of the Tertiary and Cretaceous formations of Sussex. Royal 4to. *London.* 63*s.*

GEORGE JOHNSTON, M.D., LL.D.: Introduction to Conchology, or Elements of the Natural History of Molluscous Animals. *London*, 1850. Van Voorst.

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Prof. M'Coy: The British Palæozoic Fossils, added by Prof. Sedgwick to the Woodwardian Museum. In royal 4to, with numerous plates. Part I, ready. Reeve & Benham.

Mrs. Hussey: Illustrations of British Mycology, 2nd ser. In royal 4to, with numerous colored plates. Part iii, just published. *London.* Reeve & Benham.

John Timbs: Year-Book of facts in Science and Arts for 1851, exhibiting the most important discoveries and improvements of the past year in all branches of Science and the Arts. *London. 5s.*

M. Borrell: The Numismatist—a monthly publication exclusively devoted to the familiar illustration of the science of Numismatography. Begun March 1st. *London.* J. Hearne.

Spicilegium Neilgherrense, or a selection of Neilgherry plants drawn and colored from nature. 4to, with 150 colored plates. *Madras*, 1846–1850. 4*l.* 10*s.*

Proceedings of Boston Soc. Nat. Hist.—*December*, 1850. p. 339. On the age of the red sandstone of the Connecticut valley; *Wells.*—p. 342. New Medusa, Rhacostoma atlanticum; *Agassiz.*—p. 343. New shells of Exploring Expedition (genera Mytilus, Pecten, Ostræa, Terebratula, Mactra); *A. A. Gould.*—p. 348. Development of Planocera elliptica; *Girard.*—Observations on fishes and other animals of Mammoth Cave; *J. Wyman.*—p. 354. On supposed parasites of Hydra; *Agassiz.* —p. 356. Observations on the Naiades; *Agassiz.*—p. 357. Origin of deposits of marine shells in Maine, on the St. Lawrence, and on Lake Champlain; *Desor.*— p. 358. Origin of the sands of the Ridge Road from Rochester to Lewiston, N. Y.; *Desor.*—p. 359. Sixteen new species of Melania; *A. A. Gould.*—p. 363. Observations on Planarian Worms, with descriptions of new species of Echinoderms; *Girard.*

Proceedings Acad. Nat. Sci. Philadelphia. *January*, 1851.—p. 139. On the crossing of the Dog and Wolf; *S. G. Morton.*—p. 141. Habits of Rocky Mountain Swallow; *J. P. Hazard. February.*—p. 144. New Jersey Meteorite; *C. U. Shepard.* —p. 145. On Hair; *P. A. Browne.*—p. 147. A new species of Jackal from near Fort Gibson, (Canis frustror); *S. W. Woodhouse.*—p. 149. Sketch of the Birds of the Genera Vireo, *Vieillot*, and Vireosylvia, *Bonaparte*, and list of known species with descriptions of three new; *J. Cassin.*—p. 154. Two new Birds of the Genera Galbula and Bucco, *Briss.*, in collections of Acad.; *J. Cassin.*—p. 155. New species of Entozoa; *J. Leidy.*—p. 156. On two Mexican Wolves, Canis Mexicanus and the Canis frustror; *Dr. Berlandier.*—This number of the Proceedings contains two plates, Pl. 3, of Emberiza bilineata, *Cassin*, and Pl. 4, Emb. Belli, *Cassin.*

Astronomical Journal, Contents for NO. 21, Jan. 18.—Continuation of the Investigation of Change of Place in the fixed Stars; *E. Schubert.*—From a letter of Professor Goldschmidt to the Editor.—From a letter of Mr. Graham to the Editor.— Observations of Hygea, made with the Filar-Micrometer of the Washington Equatorial; *J. Ferguson.*—Elements and Ephemeris of Clio.—Egeria.—NO. 22, February 14. —Elements and Ephemeris of Clio.—From a letter of Professor Hubbard to the Editor.—Zodiac of Clio.—Occultations of Stars observed at the Cambridge Observatory in the years 1846, 1847, 1848, 1849, 1850.—Death of Prof. Schumacher.—NO. 23, March 14.—Observations on Hebe, Iris, and Egeria, made with the Filar-Micrometer of the Washington Equatorial; *J. Ferguson.*—Elements and Ephemeris of Iris, for 1852; *E. Schubert.*—Observations of the First Comet of 1850, made at Hudson, Ohio; *E. Loomis.*—On the Similarity of Arrangement of the Asteroids and the Comets of short period, and the possibility of their common origin; *S. Alexander.*

Note.—*Professor Page's Electro-magnetic Locomotive.*—We learn from the National Intelligencer, that on Thursday last, [Mar. 27,] Prof. Page made a preliminary trial on the railroad, for the purpose of testing the best mode of attaching the battery, which seems to be a difficult point, owing to the jostling and oscillations of the locomotive. It was run out over two miles, and the best speed on a straight track was ten miles an hour. The locomotive weighs ten and a half tons, and has five feet drivers, with two feet stroke. The Intelligencer says it looks exactly like a passenger car.

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